M-THUMP5-1000-UG-EN-V01
May 2023

User Manual

Portable
Fault Locating System
M-THUMP5-1000

Read this entire manual before operating.

Megger.
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Phoenixville, PA 19460
U.S.A.

610-676-8500

www.megger.com

Portable Fault Locating System
M-THUMP5-1000

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)

1

SAFETY

Precautions

This manual contains basic instructions on commissioning and operating the M-THUMP5-1000 system. For this reason, it is important to ensure that the manual is available at all times to authorized 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:

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. The user must consult the User Guide when this symbol marked on the instrument.

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-energize, protect against re-energizing; 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.

A trained or authorized electrician may only install the system. 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 nonconductive 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 firefighting, 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 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.

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)

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*.

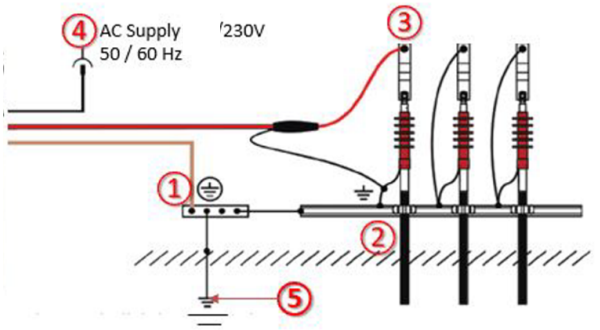
2. High Voltage Return (= shield of test lead) ② is connected via clamp to concentric neutral (shield) of power cable to be tested or to the grounded second faulty core in case of belted MV cables or to the second faulty core of a LV cable.

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.***



Resistance between grounding point of power device ① / ② and system earth and earth ground ⑤
must be ≤ 5Ω

NOTE: the safety ground (earth) conductor of the AC power cord ④ is ***not a sufficient ground when discharging a high voltage surge capacitor***

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TECHNICAL DESCRIPTION

System Description

Functional Description

The M-THUMP5-1000 is a compact fault location system typically to be used for fault locating of LV and lower voltage MV power cables. It offers either a 120V or 230V AC power source to operate, which is connected in line with an internal isolation transformer to the AC shore power source.

The M-THUMP5-1000 is ideally suited for fault locating of both LV and lower range MV circuits. The M-THUMP5-1000 qualifies for all type of cable insulation materials, XLPE, EPR, PVC* and also PILC. The main advantages of the M-THUMP5-1000 are its solid HV performance featuring 1,000J output, 5kV Hipot (70mA) with IR measurement, 5kV/1000J ARM / Multishot & ICE prelocating, unique 1/5kV Burn ARM prelocating with 500/ 70mA, 1/5kV Burning with 500/ 70mA , 5kV acoustic pinpointing and 5kV ground /sheath fault locating. In addition, it features the easiest operation in the marketplace with an intuitive GUI, automated fault locating process and is capable of operation in rainy environments, its weight is 50kg (110 lbs.).

* PVC insulated LV cables can cause a very substantial attenuation of the TDR pulse, which might negatively influence the automatic cable end identification.

Product Model

Currently, only the portable M-THUMP5-1000 is available (M9 model), it features 4 sturdy handles for lifting and is available as AC ONLY unit with internal isolation transformer.

Features

The M-THUMP5-1000 system combines the following features and functions in a fully integrated, microcontroller and SW operated device:

- ***Quick Steps***, ***Expert Mode,*** and ***Manual TDR Mode***, allowing to address 3 levels of user skill:

  Quick Steps and **Expert Mode** provide ***Automatic ARM fault Pre-location*** and ***Sectionalizing*** (latter requires optional SW, typically only for North American single phase MV circuit designs applicable).

  Quick Steps and **Expert Mode** provide ***Automatic cable end and fault detection and localization***

  Manual TDR Mode*,* if selected by user, ***all of the 20 TDR features are always available*** *on the GUI (graphic user interface)* ***& must be manually selected / adjusted*** by the user; *all* ***automatic adjustments*** known from Quick-Steps and Expert mode ***are disabled*** in **Manual TDR Mode !** This mode caters to the ***group of users*** who prefer to operate the TDR according to their own experience and expertise ***without any algorithm intervention.***
- TDR with extreme user-friendly phase comparison feature (up to 256)
- ARM Prelocating ***with Multishot***, 0-5kV
- ICE Prelocating, 0-5kV
- ***Burn ARM Prelocating with Multishot***, 0-1kV / 0-5kV
- Burning ***0-1kV, max. 500mA***, 1-5kV, max. 70mA
- Optional Sectionalizing SW for 5 & 6.6kV MV circuits
- DC test up to 5 kV with automatic breakdown detection and insulation resistance measurement
- Pinpointing of high resistance faults in surge mode (0-5kV)
- Ground Fault (Sheath) test with breakdown detection (0-5 kV)
- Ground Fault (Sheath Fault) pinpointing (requires optional receiver ESG-NT) (5 kV 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)
- Sturdy and dust /weatherproof enclosure for outdoor use, IP53 featuring a heavy-duty deep dish molded bottom pan

Scope of Delivery

The scope of delivery of the M-THUMP5-1000 system comprises the following components:

- HV output cable (hard wired)
- Safety Ground cable (hard wired)
- AC Power cord
- Owner's manual

Available Accessories

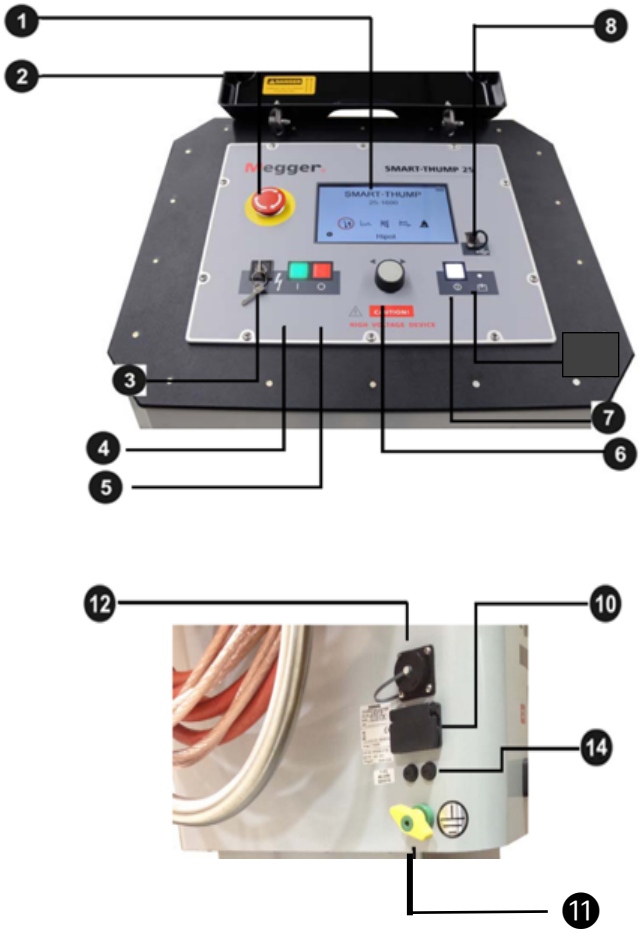
The following accessories* can be ordered from Megger, if required:

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_V05***

Parameter	Value
DC Test voltage	0 to 5 kV
Surge voltage	0 to 5 kV
Burn current	500 mA (up to 1kV) 70 mA (up to 5kV)
Insulation resistance measurement	2 kΩ … 10 MΩ
Surge energy	1000J @ 5kV
AC Power Input	210-264V, 50-60 Hz, 6.3A 230V fuses
Display	7”, 1280 x 800-pixel High Brite TFT direct sunlight readable
Memory	256 traces
Interfaces	USB port
TDR Range	Up 180,000ft / 52km
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
Input power	700W / 230V
Dimensions (W x H x D)	506 x 794 x 356 mm / 20 x 32 x 15 in
Weight	111lbs / 51kg, incl. 15ft / 3.5m HV cable and safety ground cable each
Protection class (in accordance with IEC 61140)	I
Protection rating (in accordance with IEC 60529)	IP53 (open lid)

Control Elements, Indicators and Connectors



Element	Description
1	Display 7 inch
2	Emergency stop button
3	HV key switch
4	“HV ON” button
5	“HV OFF” button
6	Rotary control knob
7	“ON / OFF” button
8	USB port
10	AC power connector
11	Safety ground connection
12	Jack for connecting external safety device *(See page 10 'Available Accessories').*
14	Fuse Holders for AC input power

Power Supply

230V AC Line Operation

As soon as the AC power cord is connected between the receptacle 10 of the SMART THUMP & an AC outlet and the white ON-OFF button 7 is pushed, ***the system is operating on AC power*** ***(white button illuminated).***

If using a power cord other than the one provided or an extension cord, ensure it is rated for at least 250VAC and is at least 17 AWG (1mm2).

Do not use inadequately rated power cords!

The M-THUMP5-1000 is equipped with an internal isolation transformer to protect against poor grounding conditions on the 230V supply side.

3

SETTING UP THE SYSTEM

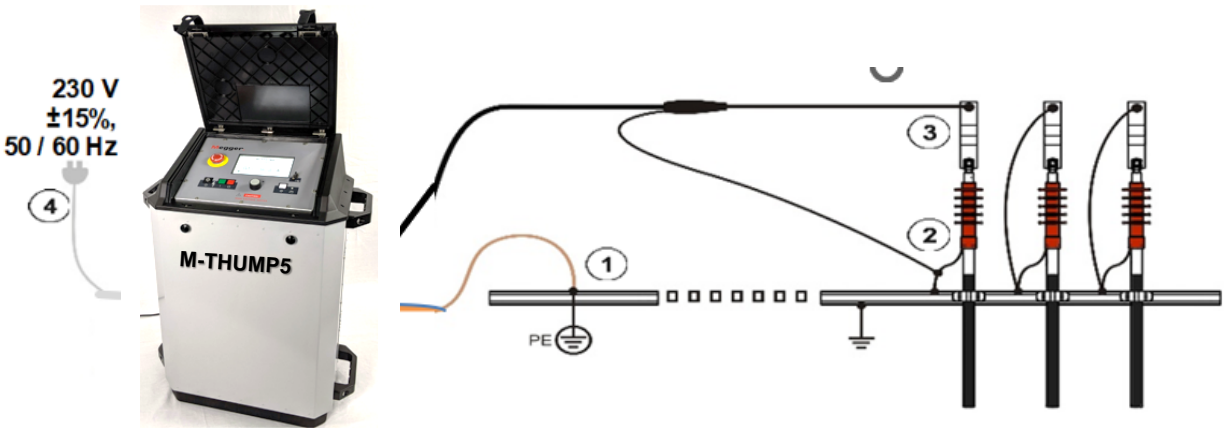
WARNING - Safety instructions for setting up

- 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 (i.e., the German BGI 5191)

  Operator must inform him/herself 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 **five safety rules** (see page 3) - 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 M-THUMP5-1000 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 3 and 4.



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 ***unless*** the device has no ground connection to earth ground! IMPORTANT: if a separate earth ground rod must be driven as typical in some countries (at least 6ft!!), the HV Return ***must be jumpered*** to the same earth ground rod, *otherwise the F-OHM safety circuit will be activated and will prevent the activation of any HV mode!*
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).*

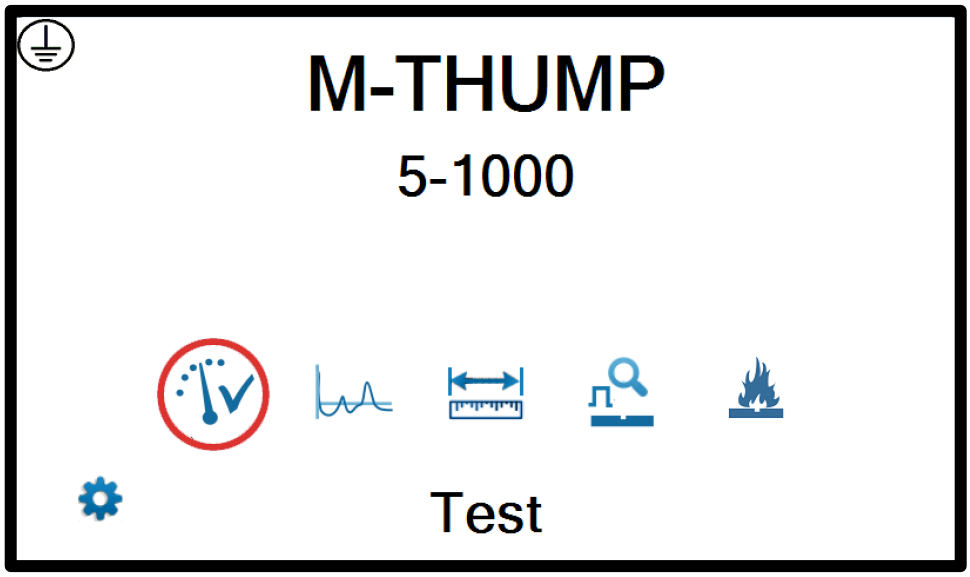
Step	Description
4	**Connect the supplied power cord** to the connector ⑩ on the back of the unit and connect the other end ***to single phase*** 230V AC power.
5	Only after all necessary connections have been made, **the ground connection to the cable under test shall be lifted.**

4

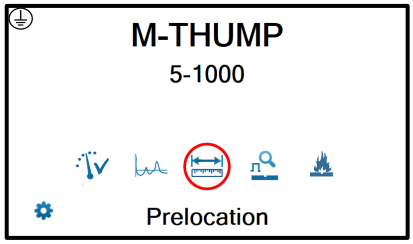
OPERATING INSTRUCTIONS

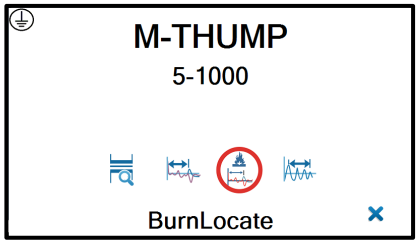
Power up the System

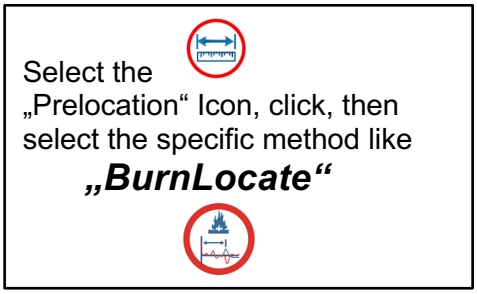
Once the "ON / OFF" button ❼ is pressed, the system starts up. After start-up, *the system* is in the 'Ready for operation' state, *remains grounded*
as indicated by the grounding symbol in the upper left-hand corner of the screen ***and*** the ***main screen*** is displayed:



The main screen image shows can show up to 5 icons for different operation modes. More modes can be selected by the user in the expert mode under "UNIT CONFIGURATION", in this case the displayed icons represent *types of operation (in this example PRELOCATION)* and by clicking on them display the individual modes







Basics of Operation

Operation with Rotary Knob

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

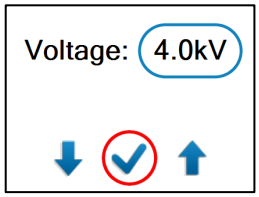
Turning ⇨ **Selecting**

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

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

not selected **selected**

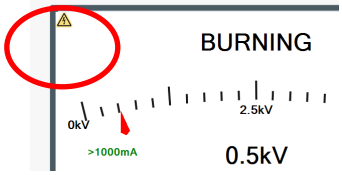
With the aid of the rotary knob, the individual menus can be accessed, and values can be entered. ***If a selected menu item requires a value*** to be adjusted, the following dialog is displayed:



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

High Voltage Control

Before the start of any HV test, the user is prompted to enable high voltage, provided all safety requirements are met. To start HV, the green illumina-ted "HV ON" button ❹ (green) must be pushed. This disconnects the dis- charge resistor and enables the generation of high voltage. The red illumina- ted "HV OFF" button ❺ signals that the HV output is now energized (hot) and the green button goes dark.



Additionally the *HV symbol is* displayed in the upper left-hand corner of the screen

The activation of high voltage requires that all conditions of the safety circuit are met, see this page below under *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 2aborted and the high voltage power supply is turned off and the entire test circuit including the M-THUMP5-1000 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 screen 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 Multi-shot 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 configured 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 TDR Mode (password protected:**
  The Manual Mode is activated after accessing the DEFAULT *settings and selecting MANUAL MODE of OPERATION*.

  NOTE: 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** ***are disabled*** and ***must be adjusted manually***.

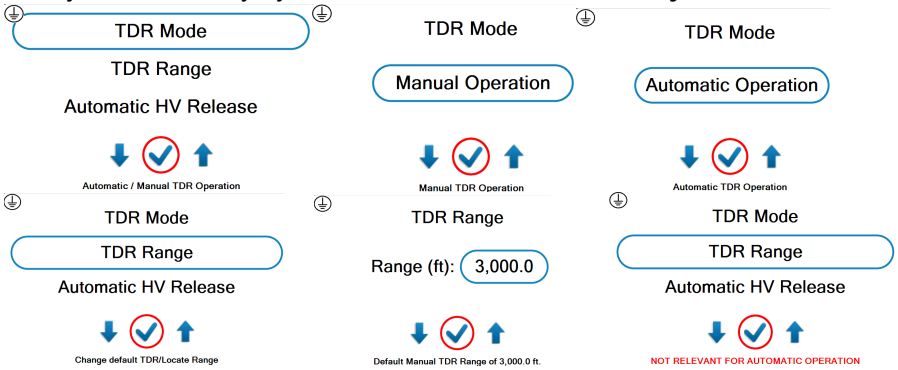
For detailed information on how to switch modes, please refer to the next paragraph below.

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**, the system settings icon is displayed, by clicking the scroll down *system set up menu* is available:

Menu item	Description	
Leave EXPERT MODE	By leaving the expert mode through this menu, after scrolling all the way down and click RETURN, any new settings are saved and the system is switched back to the scroll down menu, defaulting to LEAVE EXPERT MODE, when clicking the SW will revert back to **QUICK STEPS mode**. The ⚙ icon 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.	
>> Trigger delay time	**NOTE:** ***All M-THUMP5-1000 Models feature automatic Multishot (Trigger delay time not applicable)***	
>> TDR - Mode Selection **TDR – Range default setting (must be set in manual mode !!! between 150m and 15km (500-50,000ft)**	***AUTOMATIC TDR Operation*** means that the software utilizes algorithms to determine the end of the cable, the distance to fault, automatically sets 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 adjusted manually by user; ***all*** TDR features are ***always*** available on screen 	

Menu item	Description
>> **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 ***HV***, after having 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*).
Voltage selection *manual* or *automatic*	When set to **Manual** the unit will always default to 0.1 kV 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 M-THUMP5-1000 Unit is set to Manual Voltage Selection in order to avoid an automatic 5kV HV build-up, which might be unexpected by the operator if not 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 5 kV voltage; when in thump mode it raises the voltage to maximum 5kV (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 4 kV, i.e. breakdown 4 kV, thump voltage will be set to 5kV; even this selection is made automatically the user can always 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 a minimum of 0.1kV and a maximum voltage of 5 kV
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 also 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 (applicable for TDR, ARM and Burn-Arm, <u>not</u> ICE)</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 M-THUMP5-1000 at the end of the typical 50 ft (15 m) 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 50 ft (15 m), 85 ft (25 m) or 130 ft (40 m).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 and <u>should only be changed if the length of the connection cable is changed.</u></td></tr>
<tr><td rowspan="5">Cable List (applicable to TDR, ARM, BurnArm and ICE Prelocation methods)</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 53) 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>AUTO Shut Down</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) and Burn-Arm Mode, 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 however can be saved via the feature „SAVE CURRENT TRACE", please see chapter 6, CUSTOMIZE TDR FEATURES*
System information	The ***entire*** hardware and software configuration of the unit ***are displayed ONLY!***
Change password	To change the password (***not recommended***), **EXPERT MODE** must be enabled.
System Configuration	
	Aside from *to the* ***factory preset unit configurations****, which are* ***not accessible*** *to the user, he* ***has access*** *to choose amongst* ***7 fault locating features****.* ***When selected****, a specific icon for each of the features will either appear on the main screen (see page 18, Power on the System) or under an umbrella icon.*
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, Burn-Arm or ICE. In this mode the TDR is performing low voltage (<60V) time domain 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 unshielded LV cables
Burning 	Burning is typically applied to a known failed cable in order to reduce or increase its fault resistance. This is sometimes required in order to create a flashover in order to locate and or pinpoint the fault, ***typically used in PILC or LV cables***
BurnArm Locate 	Is a Prelocation method for a cable with a very low fault resistance, where the application of the burn function is coupled onto the live TDR trace; the moment the burn current is able to create an arc, the TDR will capture the negative reflection of the TDR pulse created by the short circuit the arc generated between conductor and shield (MV cable) or between 2 conductors (LV cables) and indicate the fault location and distance
Burn-Arm Locate Time out	The duration of the Burn-Arm Locate application is limited to either 1, 2 or 3 minutes, after which time the fault trace is automatically captured. However, the user can independently of the automatic capture initiate a manual capture at any time within the selected time window.

Menu item	Description
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.
Sheath Fault Locating 	Is typically performed after a “positive” sheath test (fault detected). 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
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
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 for Manual TDR Operation,*** *please see page 22*
Return	By leaving the **EXPERT MODE** through this menu item, the new settings are saved.

5

HOW TO PERFORM A TEST

Fault Locating in Shielded Medium Voltage Power Cables

Locating a Faulty Cable Segment (***Sectionalizing***, typical in North American MV URD Loop circuits)

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 impedance changes that are related to the cable end and the transformers. The latter ones indicate the location of the transformers. A second reflection 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.

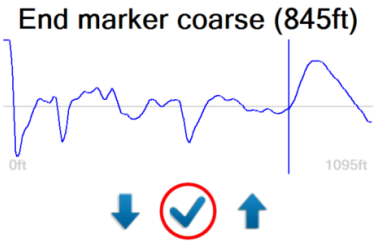
With both traces lying on top of each other, the fault location (position where the two traces diverge from each other) is identified and the transformers reflections provide the landmarks to identify the faulted cable segment. It will be switched out by pulling the elbows to the left and right side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

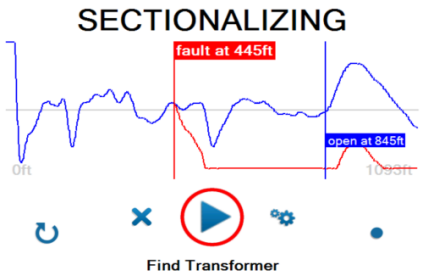
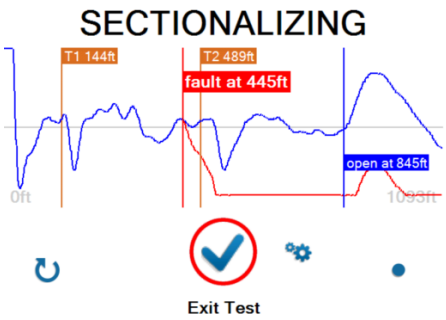
The software package to perform the fault locating method called "Sectionalizing" , if ordered by the customer, will automatically perform the following procedure:

- 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

How to Determine the Faulty Section

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 21).* **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 21.* **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 and adjusting the voltage up*
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. *See page*

How to Verify whether a cable section or point to point cable is faulted

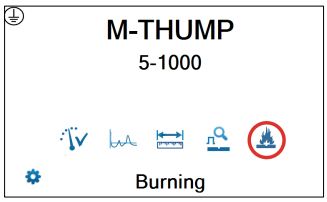
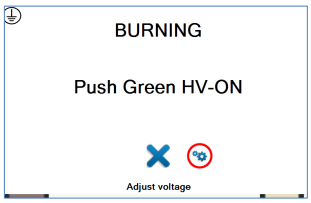
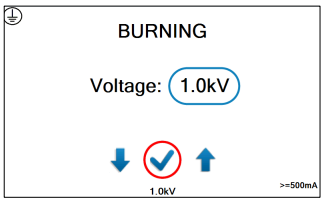
Any HIPOT test within the context of Sectionalizing must ***be done after*** the faulted section has been isolated during the sectionalizing process. It is to con- firm, that the section of cable identified as faulted can be verified to be actually faulted by the HVDC test. Proceed as follows to perform a HIPOT test *after the identified cable section has been isolated at the 2 closest transformers* (***DC Hipot test cannot be performed if transformers are connected to the faulted cable section due to their Y grounded design, creating an immediate short circuit).***
The same procedure is applied to perform a HIPOT test on any isolated power able (point to point) to establish whether it can hold full operating voltage or not (e.g., feeder cables, branch cables or radials).

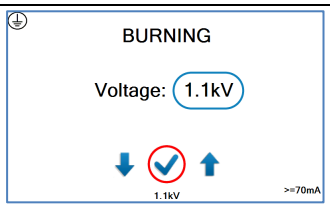
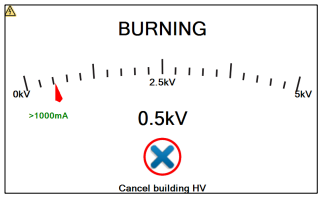
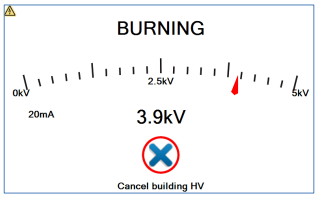
Step	Description	
1	Select the menu item from the main menu or from the submenu (depends on the system configuration).	
2	Adjust the test voltage and select to confirm the value.	
3	Press the green illuminated “HV ON” button 4.	
4	Select ▶ to start the test (only if AUTOMATIC VOLTAGE RELEASE option is set to **manual.** *See “System Settings” on page 25).*	
	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). This ***could*** mean that the ***cable is good,*** however the same result could be observed in case the cable is interrupted (cut conductor or “burnt in the clear” condition in Aluminum conductor cables), needs to be confirmed with TDR measurement, ***if true cable end is visible*** ➡ cable has no fault, ***if true end cannot be verified*** by TDR ➡ cable is faulted

Step	Description	
	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. If this condition occurs, ***BURNING*** (*see next paragraph*) ***can be tried*** to change the resistance of the damaged insulation and establish a condition (small air gap) that allows to flash the fault over either to prelocate it or to pinpoint it using the surge generator (thumper).
5	Select  to return to the main menu.	

BURNING

In case a faulted cable cannot be flashed over and having a fault resistance anywhere between 500Ω and 25kΩ, ***the burn method*** might be helpful to condition / burn the fault in order to convert it back to a flashing fault (see last paragraph above).

Step	Description
	Perform **Burn** and follow the steps listed below
1	Connect safety ground of M-Thump5-1000 to system ground
2	Connect HV Return to metallic shield of MV cable
3	Connect HV output cable to cable to be fault located
4	Select the Burn icon on the main menu screen and follow prompts
	   Select voltage range based on previous Hipot / Breakdown test (≤ 1kV, 500mA)

Step	Description
	   Select voltage range based on previous Hipot / Break-down Test (≥ 1.1kV, 70mA)

Determining the breakdown voltage of a faulted cable **(proof testing)**

A HIPOT/breakdown test is used to determine the breakdown voltage 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 5kV*** to the cable under test (automatically 5kV 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,* ***it's minimum should equal phase to ground voltage Vo (AC rms) multiplied by 1.41 (peak) = DC***
Vo can be calculated by dividing the system voltage by $\sqrt[2]{3}$ *or1.71.*
This value is equal to the AC peak value of the voltage under operation

Example: 5kV cable, *2.92V phase to ground AC rms, x 1.41 =* ***4.2kVD peak, = operating voltage phase to ground = DC test voltage***

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 23).*	
	Result: The selected voltage is applied to the cable. During the rise of the voltage the maximum current of the HVPS will be displayed on the lower left-hand corner of the screen 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, meaning there was a flash-over at the fault

Step	Description	
	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

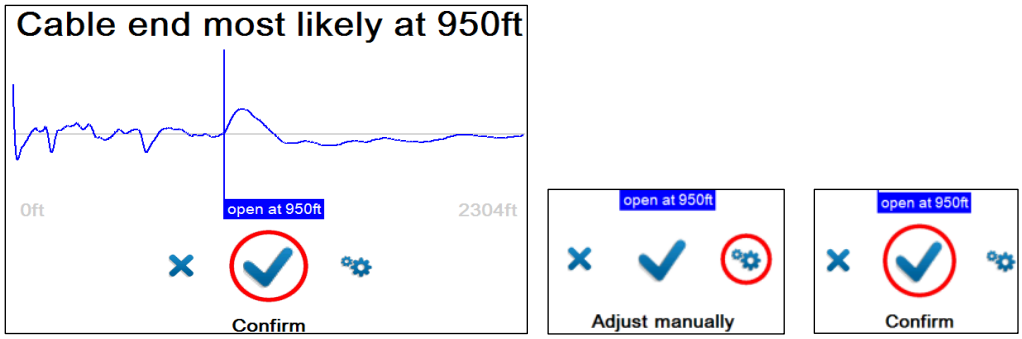
Arc Reflection Method (ARM) ***with Multishot***

For pre-location of a high resistance MV cable 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:

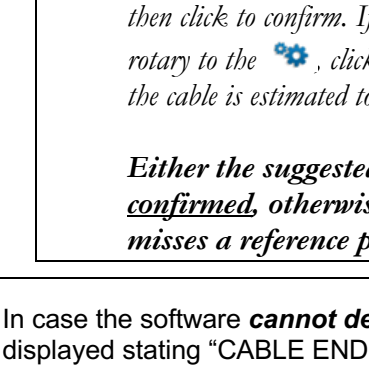
Step	Description
1	Select the LOCATE menu item from the main screen or from the submenu screen (depends on the system configuration).
	Result: A LV pulse is applied to the cable. The reflection image with the determined distance to the *cable end* is presented in the display.

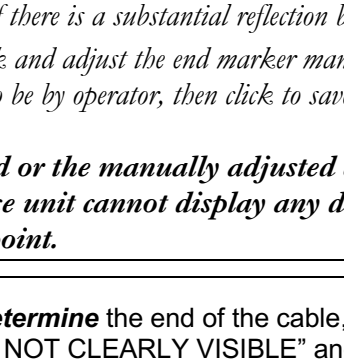


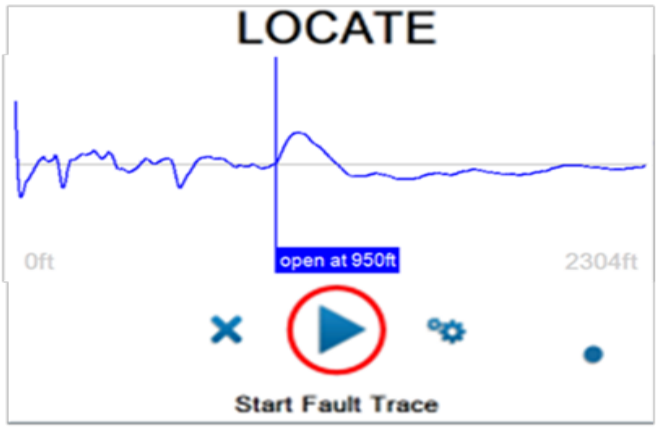
This reference trace is also called the “live” trace as it is permanently refreshed (blue color vs a black color trace indicating a “frozen” or “saved” LV trace).

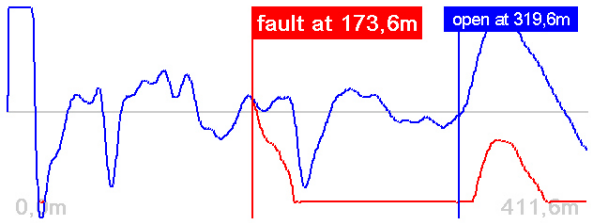
The ***cable end must be confirmed*** either by acknowledging the automatically suggested number or by adjusting it manually; it serves as ***reference for any other distance*** measurement***, without doing so, no distance measurement can be displayed***!

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 estimated to be by operator, 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).





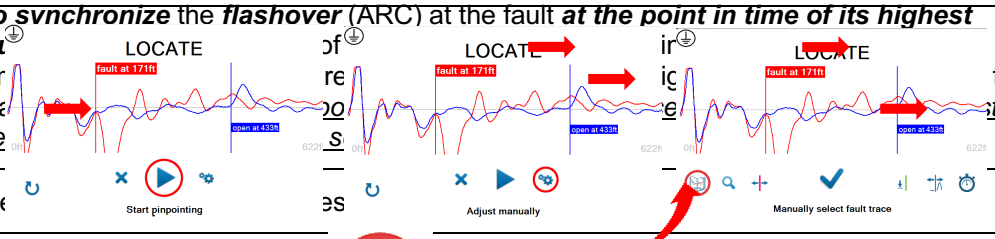


Step	Description
3	If required, the surge voltage *can be adjusted* via the icon; otherwise, the maximum surge voltage is automatically used, ***if*** AUTOMATIC VOLTAGE CONTROL has been selected as default.
4	Press the green illuminated "HV ON" button 4.
5	Select to charge the capacitor (only if AUTOMATIC HIGH VOLTAGE RELEASE option is set to **Manual.** See page 23).
	Result: The surge capacitor is charged up to 5kV 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 23).
	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 and re-try, can possibly mean "non faulted cable"* *- If message is shown on screen "no flashover detected",* means that SW algorithm could not detect fault*; user must analyze trace and move marker to fault position if he can see along the cable a substantial negative reflection of the red trace and a clear split between the blue and the red trace at that very location* *-If message appears "poor quality trace", user must click one more time and analyze trace to see if at any location along the trace a split between the blue and red trace can be seen, if so the marker must be moved manually to that location, providing distance to fault* ***Important:*** *any time the fault distance leaves room for interpretation, the test should be repeated 3 times, if results are very close, it can be assumed that this is the true fault location. If results differ, go to CURRENT DECOUPLING ICE prelocating and try to determine fault location, see next page*

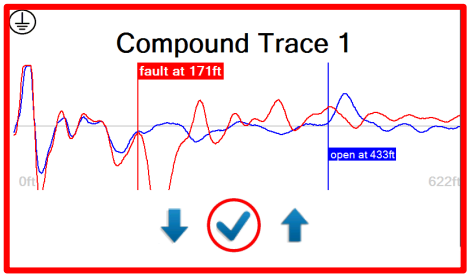
Step	Description
7	If necessary, adjust the display settings, TDR settings and marker position through the menu in order to identify the fault distance as precisely as possible.
8	Select to proceed with pinpointing or to return to the main screen.

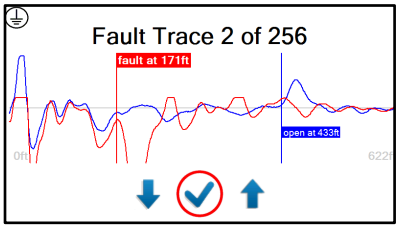
The advantage of MULTISHOT when performing ARM Prelocation

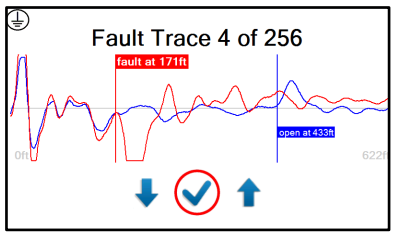
Step	Description
2	The ***Multishot*** technology ***overcomes the challenge*** of the traditional ARM Prelocation ***to synchronize*** the ***flashover*** (ARC) at the fault ***at the point in time of its highest***
1	Pe

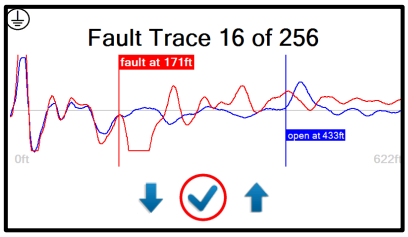


Select MULTISHOT Icon, the SW /GUI wil present „***Compound Trace 1***“, which represents the ***„best“ fault trace*** *to be* ***found by the algorithm*** by overlaying all 256 traces and averaging only those that ***the*** significant reflection at 171ft , user can scroll through any number of traces to see if there is a better match available, typically it cannot be found as shown on the ***sample screenshots*** e.g. 2,4,16 below.









The principle on which Multishot is built, is best described as „firing“ ***not only one*** TDR pulse at a time and then try to capture the impedance change based on the „quality“ of the ***synchronization between the ARC and the TDR pulse***, ***but a large number*** of TDR pulses in very short repetition (every 256nsec), creating a high probability that one of the TDR pulses will see the flashover-arc at the time of its highest current or very close to it.

	As described above, the ***algorithm will present what it deems to be the „best" trace***. The user can check this out by scrolling through individual traces, here are some criteria how to compare the quality of the individual traces to eachother in order to determine the „best" one, a few parameters are suggested to make the assessment: 1. Look for the ***best „overlay"*** of the blue and red trace ***up to fault point*** (nothing beyond!), ***this eliminates Fault Trace 2*** in the example above 2. Look for the ***most significant negative (red) reflection*** because it identifies the greatest impedance difference / higest current in the arc; it is important to keep in mind that all traces have been captured using the identical gain, zoom and pulse width, allowing them to be compared without any limitations. All 3 traces, Compound Trace 1, Fault Trace 2 and 4 look similar, it appears that ***Compound Trace 1*** has the ***largest area*** under its curve, in addition to „best" curve ***shape***, without a cut-off ***edge***.

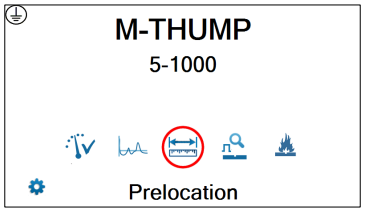
Burn ARM Prelocation Method *with Multishot*

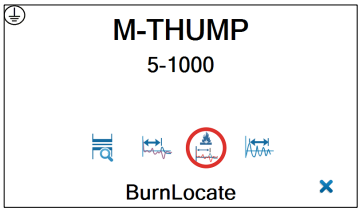
Similar to the ARM Prelocation method, which will locate cable faults provided they flash over, the Burn ARM method will also provide a distance to the fault by creating a flashover – arc at the fault.

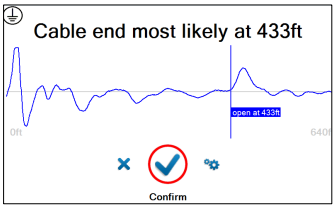
However, the ***big difference*** is that initially ***the fault is very low resistance*** and will ***not flash over*** , meaning it ***cannot be captured by ARM.***
The **Burn ARM** method combines the advantages of a burner with that of the TDR to capture and locate a very low cable impedance.
When employing this method on a low resistance (500Ω to 25kΩ) / non flashing fault, a continuous TDR pulse is coupled via a diode coupler on the output of the HV burner (M-Thump5-1000, 5kV max). The combination of the low voltage and the high current (500mA 0-1kV, 70mA 1-5kV), generates enough energy(heat) to "condition" or " burn" the compromised cable insulation to eventually *"burn the damaged insulation away",* creating an air gap*,* followed by an arc, which will be captured by the continuous pulse of the TDR as a low impedance reflection, providing the fault distance.
Principally the Burn ARM Prelocation method can be used on LV- and MV cables, either in a phase to phase, phase to concentric neutral or phase to armor configuration. The 5kV capability of the M-Thump5-1000 allows its application to all types of LV cables and MV circuits up to 6.6kV.

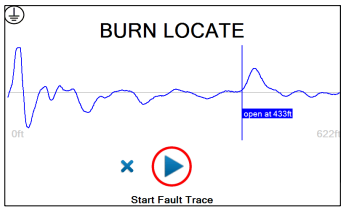
Step	Description
	Perform **Burn ARM** prelocate following the steps below
1	Connect safety ground of M-Thump5-1000 to system ground
2	Connect HV Return to metallic shield of MV cable

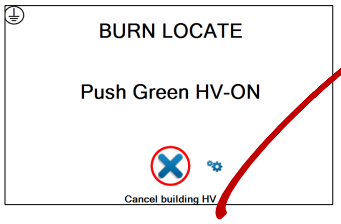
Step	Description
3	Connect HV output cable to cable to be fault located
4	Select the Burn ARM icon on the main menu screen and follow prompts

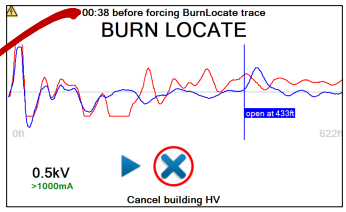






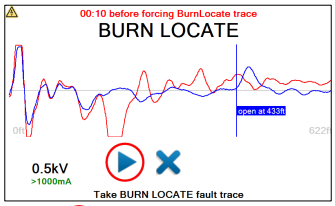




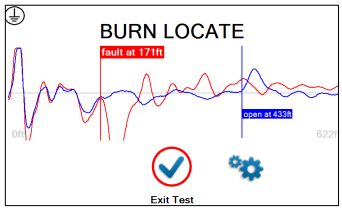


If not manually activated, unit will capture trace in 38 sec (example) due to default setting, see page XX

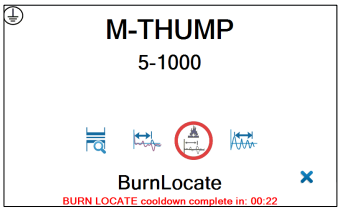
In example the "burn" voltage settled at 500V and a current > 500mA



If icon is activated, user determines the exact time to capture fault, always within the default window, see above



If user wants to "scroll through" all traces that have been captured due to Multishot feature, click on and activate Multishot
see also page 40



Current Decoupling (ICE)

The M-THUMP5-1000 SMART THUMP features the current decoupling method (ICE, Surge Pulse) as an *alternative method* to pre-locate high resistance -flashing- faults in shielded MV cables. It has proven very useful on very long (>5 mi/ 8 km) and or PILC cable fault situations, where the standard ARM pre-locating method sometimes fails to provide a concise and unambiguous ***distance to fault*** reading.

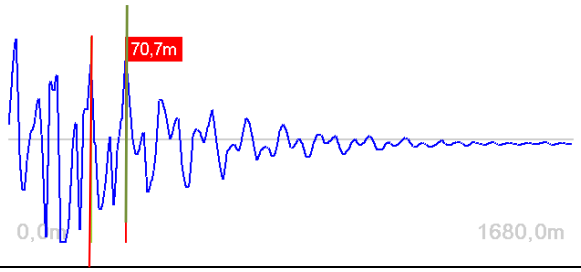
The capacitive discharge of the surge capacitor via the surge switch triggers & ignites the fault and causes it to flash over. This flashover results in a travelling current wave along the HV return. It is inductively decoupled and shown on the Reflectometer as a transient wave. Subsequently, the transient wave travels back and forth between fault and surge generator (standing wave), which is attenuated by the insulation material of the cable.

By decoupling the current signal (from HV return), an oscillating wave is displayed on the TDR screen; the distance between 2 adjacent *and* similarly shaped peaks corresponds directly to the fault distance (minus length of test lead, see below).

> ***NOTE:*** *Fault distance includes length of HV output cable: it must be deducted from the total length to obtain the distance to the fault going forward from the connection point, e.g., switchgear, transformer, 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 23.
	Result: The capacitor is charged up to 5kV.
5	Select ▶ to discharge the capacitor (only if AUTOMATIC VOLTAGE RELEASE is disabled). See page 23.
	Result: A capacitor discharge (shot) is initiated. If a breakdown occurs, a red oscillating curve is shown on the display screen. NOTE: *If no trigger is received and, no fault trace is shown, 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.

Step	Description
7	Go into the enabled 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 / surge mode is 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 or armor of a LV cable.

The M-Thump5-1000 serves as surge pulse generator to continuously feed high voltage pulses into the defective cable, producing a flashover (arcing) at the fault position (high resistance fault). The fault can be pinpointed using a magnetic /acoustic coincidence detector for best results or an acoustic only detector with distinct and well understood performance limitations. The assumption when using an acoustic detector for pinpointing is that the greatest loudness of the flashover noise will be heard at the fault location. When using a magnetic / acoustic coincidence measurement device, the exact location of the fault is mathematically determined by the smallest ***propagation time*** difference between speed of light and speed of sound, it is ***not the loudest sound***, ***but the first one after receiving magnetic signal***. The latter one is more accurate; it is the most reliable method used in high resistance fault situations (e.g., Megger Digiphone Plus) and **even for pinpointing faults in (nonmetallic) conduit**.

Proceed as follows to pinpoint a high resistance 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.

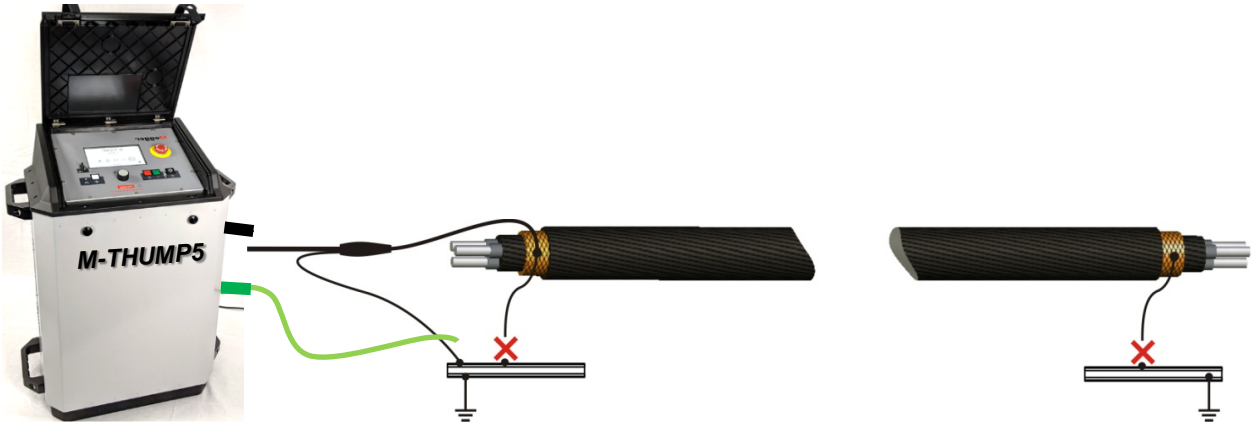
Step	Description
3	Press the green illuminated “HV ON” button ❹.
4	Select ▶ to start the thumping mode (only if AUTOMATIC VOLTAGE RELEASE option is set to **Manual,** *See page 23)*
	Result: The capacitor is charged up and a discharge takes place after 5 seconds or, if the charging takes longer, right 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 area identified by the pre-locating method, using 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

NOTE: *The methods described detects and pinpoints sheath faults in* ***shielded power cable that must have an insulating jacket over the shield / neutral.*** *It is required that the cables are direct buried and are not installed in any type of conduit, neither PVC conduit nor metal type conduit.*

IMPORTANT

In contrast to the connection diagram on page 16 the HV Output lead has to be connected to the cable shield (concentric neutral), ***which in turn must be disconnected from the com- mon bonding point on both ends*** of the specific cable to be tested. Consequently, the ***HV return lead must be connected directly to the system ground or separately driven ground rod*** (the ***safety ground*** of the M-Thump5-1000 ***must be bonded to the same ground point***!



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

With a sheath test the insulation resistance of the cable jacket can be tested by applying a DC voltage max. 5 kV between the cable shield (concentric neutral) and ground. Any leakage is indicated by a low insulation resistance and identifies 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 ❹.	
5	Select ▶ to start the test (only if **Measurement Start** option is set to **Manual**. *See “System Settings* on page 20).	
	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* (see next page):	
	Breakdown at … kV	A voltage breakdown took place at the indicted test voltage.
	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 or very low resistance 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.

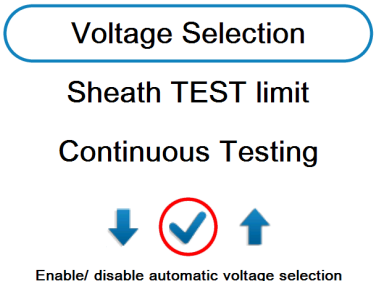
Step	Description
6	Select ▶ to proceed with sheath fault pinpointing or ✕ to return to the main menu.

How to Pinpoint a Sheath Fault in a Shielded Medium Voltage cable

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 is performed with the M-Thump5-1000 as a HV pulse generator (limited to a max. 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 pin- point 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 21)* 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, the pulse voltage can be adjusted by selecting the menu item.

Step	Description
6	Pinpoint the sheath fault with an earth fault locator like the Megger ESG-NT. For detailed instructions, please refer to the user manual for the earth fault locator.
7	Select ✕ to stop pulsing.

Fault Locating Low Voltage Power Cables

When performing fault locating on LV power cables, the same methods as described in this instruction manual under Medium Voltage Cable Fault Locating (see section 5) are applied.

However, there is significant differences in designs and constructions between LV cables and MV cables.

MV cables are typically single-phase cables, with a center conductor, a concentric neutral and a cable jacket. In case where 3 core cable designs are used today, there are 3 single core cables, which are triplexed and typically held together by a common outer jacket .

In all fault MV locating situations the HV output lead from the test equipment is connected to the center conductor and the HV Return to the concentric neutral of the cable under test (the only exception is regarding the sheath test and sheath fault pinpoint- ting, see relevant chapters in this manual).

LV cables typically feature 3 or 4 conductors (2 hot legs and a neutral, 3 phase conductors plus a neutral conductor). All these cables are unshielded, but in some parts of the world they have a metallic armor. which allows to fault locate them like MV cables provided the fault is between a phase and the armor.

The big difference between fault locating MV and LV cables is reflected in the connection of phase conductors to the HV output and HV Return leads of the fault locating set.

In most cases the output leads from the test set are connected either between 2 phases or between phase and armor (if applicable) or between phase and earth ground, depending on where the damage in the cable occurred.

It is important to recognize that all TDR related methods must be always connected between 2 phase conductors or phase and metallic armor, earth ground.

The next page provides a generic outline of a LV fault locating procedure that is applicable in many situations. It is up to the operator to select the individual steps that seem to be relevant in a particular situation, following the procedure in its entirety is recommended if no or only little facts regarding the particular fault are available.

Below a link is attached, which provides access to an article on the methodology and field experience of LV fault locating

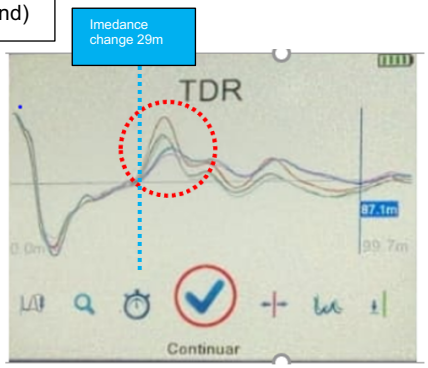
2023 - Transmission & Distribution Issue 1 2023 (zmags.com)

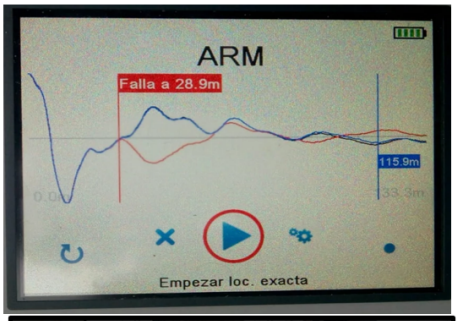
Suggested generic fault locating procedure for LV power cables

1. ***Check insulation resistance of each conductor individually incl. neutral to ground (see matrix below)***
2. ***Compare all unique conductors pairs by TDR to detect any impedance changes (use similar matrix)***
3. ***Determine fault type based on results from 1. and 2. and determine involved conductors***
4. ***If flashover between 2 conductors is possible, TDR ARM or ICE pre-location provide distance to fault***
5. ***If no flashover, the application of BURN-ARM Reflection can provide fault distance***
6. ***For both 4. and 5. use surge / thump to pinpoint***

Phases 1-3, N=Neutral, AR= Armor
(in this case armor was bonded to ground)

	L1	L2	L3	N	AR
L1	X	5kΩ	45kΩ	<20kΩ	X
L2	X	X	<2kΩ	<2kΩ	X
L3	X	X	X	<20kΩ	X
N	X	X	X	X	X
AR	X	X	X	X	X





6

CUSTOMIZE TDR FEATURES
(applicable to TDR, ARM, Burn-Arm and ICE Mode)

Introduction

As soon as a trace has been recorded and is shown on the display, the operator can access up to 16 TDR Features in order to optimize the trace and display settings (there are some exceptions regarding the ICE mode, which does not feature an active TDR pulse but is a transient method). The system configuration allows the user to display each of the 16 features as one of *2 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, located in the lower part in the center of the screen*

Enabled options, are activated by user when needed and *are displayed along the bottom of the screen.*

NOTE:	*The selection of available features depends on the system confi- guration and the active user mode. All TDR features are con- figurable by the customer to best fit his requirements in terms of technical benefit and operator skill level, both independently in from each other Quick Steps Mode and Expert Mode.* *In general, the majority of features listed is made available when working in **EXPERT MODE** (see page 51); 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 51)*

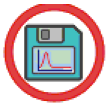
Customize TDR Features

The following table lists and describes all TDR features included in the system. A number of those *had to be set up by the user* within the default section (see page 22).
During the live operation of the TDR the *user can always override* any default value by choosing his or her own value, the changed value will be returned to the default setting after the next re-boot.

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. The physical appearance of the trace does not change, however any length measurement, e.g., the length to the end of the cable. *This menu option is only effective*, if the **Rate** parameter is set to **Meter** or **Feet, *which are the typical settings***, *see page 21*. You may either manually adjust the value or automatically adopt the value by identifying /selecting a cable from the cable list. *See page 24.*
 **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, clicking again returns the screen to the un-zoomed view
 **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>Description</th></tr>
<tr><td> 
Copy trace to screen

makes copy of live trace, helpful to superimposing several traces</td><td>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 making a phase comparison on 3 or 4 conductor LV power cables or on multistrand control cables
-Typically any unexpected impedance difference in one pair itself or between 2 or multiple pairs of conductors is indicative of a fault and its location, provided the fault is <u>either</u> an “OPEN” or a “SHORT” (in both situations 100% reflection positive or negative) <u>or</u> shows an impedance difference when comparing the impedance between 2 or more conductor pairs (e.g. 3 conductors = 3 pairs, 4 conductors 6 pairs)</td></tr>
<tr><td> 
Set Marker at Current Cursor Position</td><td>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>Saves the current screen view to the internal memory.</td></tr>
<tr><td>Export, Recall or Delete Stored Traces
  </td><td>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:

<table><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></td></tr>
</table>

Menu item	Description
Adjust Trigger Delay Time	The Multishot feature eliminates the need for a timed trigger delay
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 shorter ranges but at higher 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 MV single phase loop type circuits!*
Find Transformers in Actual Trace	Allows manual start of the transformer search.
Disable live trace/ Enable live trace	Disabling both "Disable live trace & Enable live trace" results in a continuous "live" trace recording at all times ***For most operators it is beneficial to "disabling both features", which means the trace is always live and <u>any adjustment becomes immediately visible.</u>***

Completing the Operation

After the fault location procedure has been finished, the system is switched off 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 beforehand.

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 24)*. 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>	

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 24).
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.
5	Import the new cable list into the unit. See page 24.
6	Set the new cable list as default cable list. See page 24.

How to Setup Customer-Specific TDR Features

Thanks to the high level of configurability of the M-Thump5-1000, the TDR features for both, "EXPERT MODE" and "QUICK STEPS MODE", (see page 20) are individually customer configurable.

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

<table>
<tr><th>Step</th><th colspan="3">Action</th></tr>
<tr><td>1</td><td colspan="3">Enable the EXPERT MODE. See page 21.</td></tr>
<tr><td>2</td><td colspan="3">Access the expert settings via the  menu item.</td></tr>
<tr><td>3</td><td colspan="3">Select the Customize TDR Features menu item.</td></tr>
<tr><td>4</td><td colspan="3">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 colspan="2">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 colspan="2">… select the Expert menu item.</td></tr>
<tr><td>6</td><td colspan="3">Select the option you want to enable / disable. An overview table of all options can be found in appendix 1.</td></tr>
<tr><td rowspan="4">7</td><td colspan="3">Select one of the available options by rotating the rotary knob  .</td></tr>
<tr><td>Disabled</td><td colspan="2">The option has been disabled in the selected user mode.</td></tr>
<tr><td>Enabled</td><td colspan="2">The option has been enabled to be available in the Standard Options menu of the selected user mode.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>8</td><td colspan="3">Confirm the selection with  .</td></tr>
<tr><td>9</td><td colspan="3">If required, perform steps 6 to 8 for further options.</td></tr>
<tr><td>10</td><td colspan="3">The adjusted configuration can be shared among units using the Export and Import functions of the Menu Locate Options menu; this feature is helpful to ensure that all units in a user pool are all configured the exact same way.</td></tr>
</table>

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

The M-THUMP5-1000 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.

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 5 x 20 mm 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

Feature	Recommended settings	Mark Your settings with X			
		QUICK STEPS MODE		EXPERT MODE	
		Disabled	Enabled	Disabled	Enabled
Cable Velocity (option to adjust the cable velocity)	QUICK STEPS: **enabled** Expert: **enabled**				
Xfmr sensitivity (option to adjust the transformer sensitivity)	QUICK STEPS: **disabled** Expert: **enabled**				
Delay time , n.a. for Multishot unit	QUICK STEPS: Expert:				
Disable live Trace (option to *disable* live trace recording, not recommended)	QUICK STEPS: **disabled** Expert: **disabled**				
Enable live Trace (option to enable live trace recording, 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: **enabled**				
Gain (option to adjust the gain setting)	QUICK STEPS: **enabled** Expert: **enabled**				
Put Trace on hold (option to put live trace on hold)	QUICK STEPS: **enabled** Expert: **enabled**				
Adjust End Marker (option to adjust the end marker)	QUICK STEPS: **enabled** Expert: **enabled**				
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: **enabled**				
Cursor (option to move the cursor)	QUICK STEPS: **enabled** Expert: **enabled**				
Additional Marker (option to place an additional marker)	QUICK STEPS: **disabled** Expert: **enabled**				
Pulse width (option to adjust the pulse width)	QUICK STEPS: **disabled** Expert: **enabled**				
Save trace (option to save the current trace)	QUICK STEPS: **enabled** Expert: **enabled**				
Save Fulltrace to USB (service only)					
Zoom In/Out (option to zoom the trace in and out)	QUICK STEPS: **enabled** Expert: **enabled**				