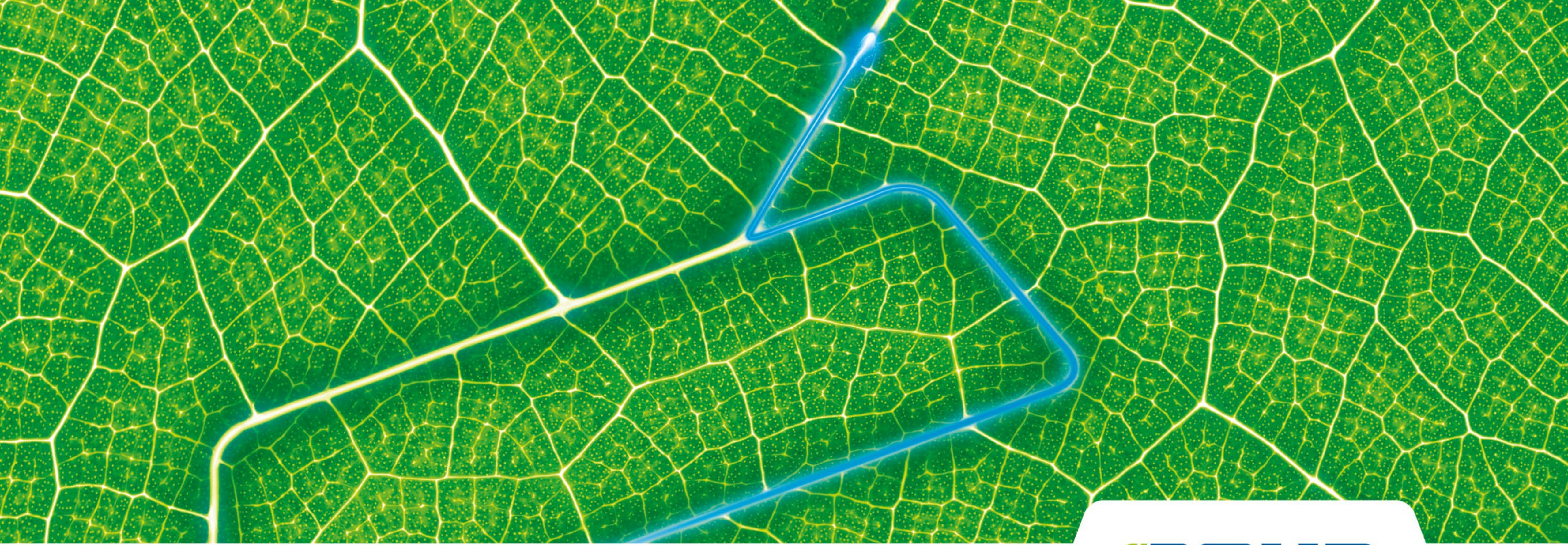

ensuring the flow

Cable fault location

Fault event-oriented maintenance of low-voltage and medium-voltage cables

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- What are the causes of cable faults?
- What are the different cable types?
- Sequence – cable fault location
- What solutions does BAUR offer?

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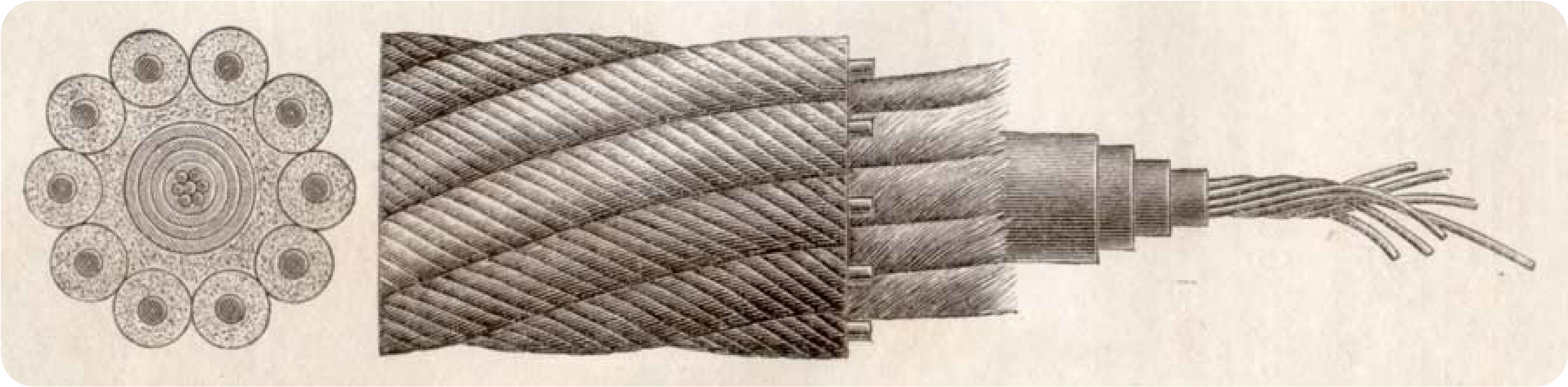
From the annals of cable lore

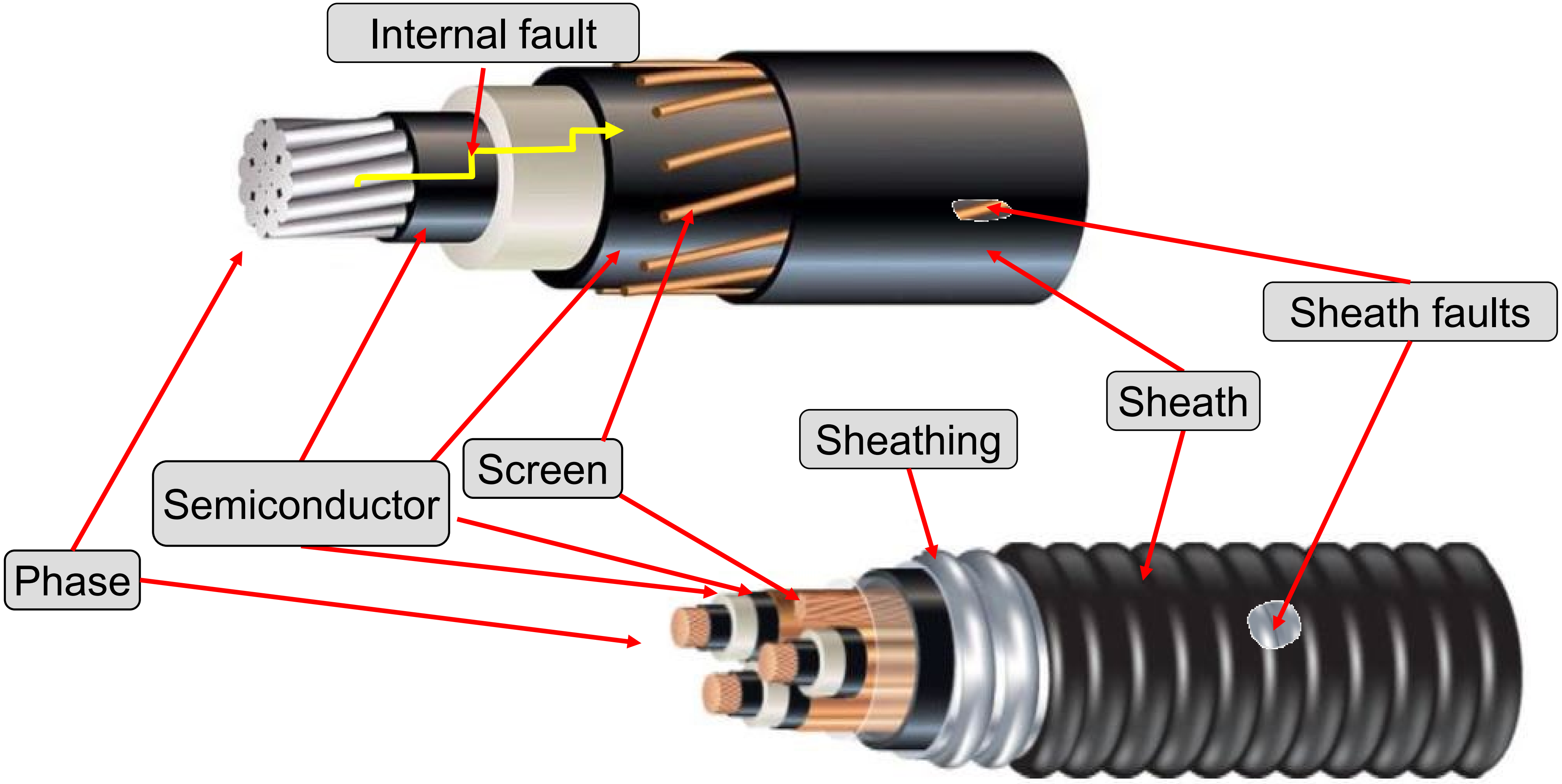
The term "cable" originates directly from the Arabic and refers to a ship's rope.

كابل

The cables that were originally manufactured in the early days of electrification looked quite similar to a tarred ship's rope, as they were wrapped and insulated with gutta-percha stranding. Paper was later used for insulation.

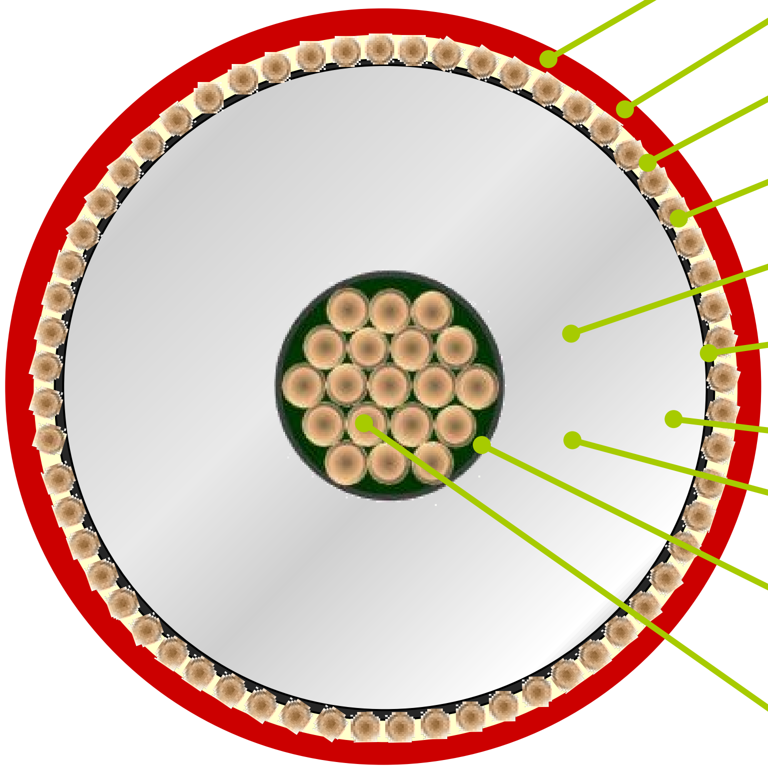


Cable structure and faults



What are the causes of cable faults?

What causes damage to cables?



- Corrosion/ageing of the sheath
- Mechanical influences
- Moisture due to sheath faults
- Screen corrosion
- Material defects
- Ageing of contact surfaces and the semiconductor, delamination
- Structural changes
- Formation of trees
- Electrochemical change to the internal semiconductor
- Mechanical stress and contact corrosion on the phase

BAUR ensuring the flow

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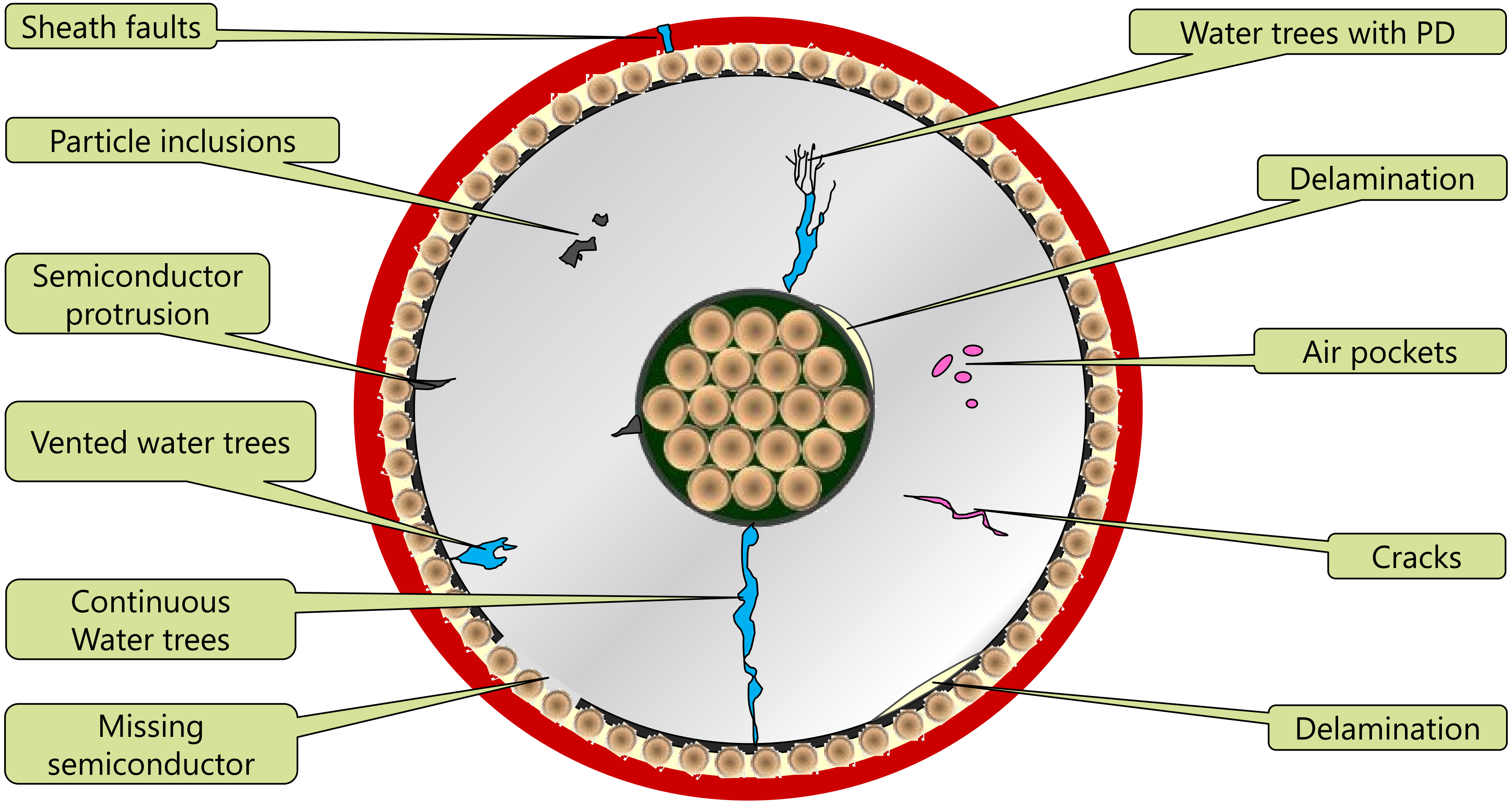
Causes of problems in XLPE cables



Other causes of cable faults

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- Electrical changes, excessively high current, voltage, or load change
- Poor workmanship of joints and terminations
- Delamination, especially on PILC cables and joints
- Strong mechanical forces in the event of short-circuits
- Environmental influences on exposed cables
- Landslides and earth movement
- External damage (e.g. during excavation)
- Temperature fluctuations and overheating
- Severe bending
- Ageing effects

What are the different cable types?

Cable types

Wet

Oil-filled cables

PILC

- With lead sheath
- With PE/XLPE plastic sheath

Dry

PE

- With graphite-coated outer semiconductor

XLPE

- With extruded outer semiconductor
- With peelable outer semiconductor
- With graphite-coated outer semiconductor (first generation of cables)
- With open screen (primarily US types)

TR-XLPE

- Tree-retardant XLPE

EPR

- Rubber cable

PVC

- Primarily used in LV and power station applications (MV)

Paper-insulated mass-impregnated cables (PILC)

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- Paper-insulated cables
- First technology for the mass production of cables
- A lot of experience required for assembly
- Still used for high-voltage cables
- Environmental problems due to the impregnating oil
- Lower sensitivity to problems

Lead sheath corrosion on a PILC cable

600 kilovolt HVDC mass-impregnated submarine cable

Material

PILC disadvantages

- Environmental problems (oil, lead)
- Installation is more difficult
- Servicing required (oil)
- Higher production costs
- Temporary self-healing

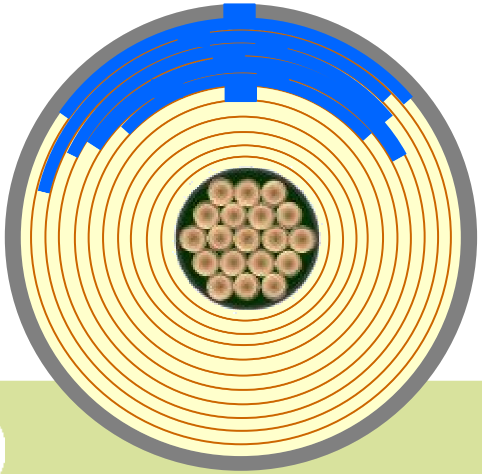
PD traces in a dry paper cable

PILC problems	Approach	
Corrosion of the lead sheath	Tan δ	
Water/moisture	Tan δ	
Drying of the oil impregnation	PD	+ VLF
Oil migration on inclines	PD	+ VLF
Problems with joints	PD	+ VLF
Polymerisation – hardening of the oil	Tan δ / PD	

Partial discharge (PD) in paper-insulated cables

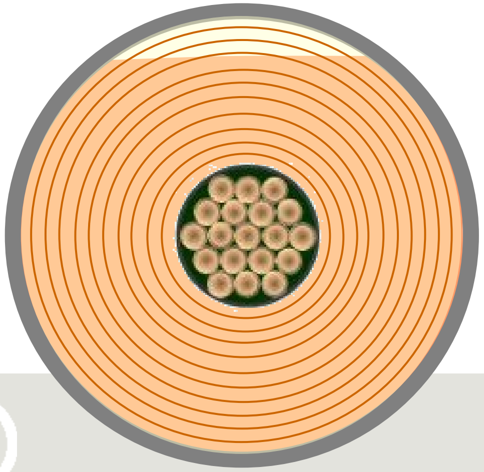
Damp insulation

Water ingress



Water ingress reduces
the effective insulation thickness, the field strength and load in the residual insulation increase, and the dielectric strength
decreases. Gradual damage until failure

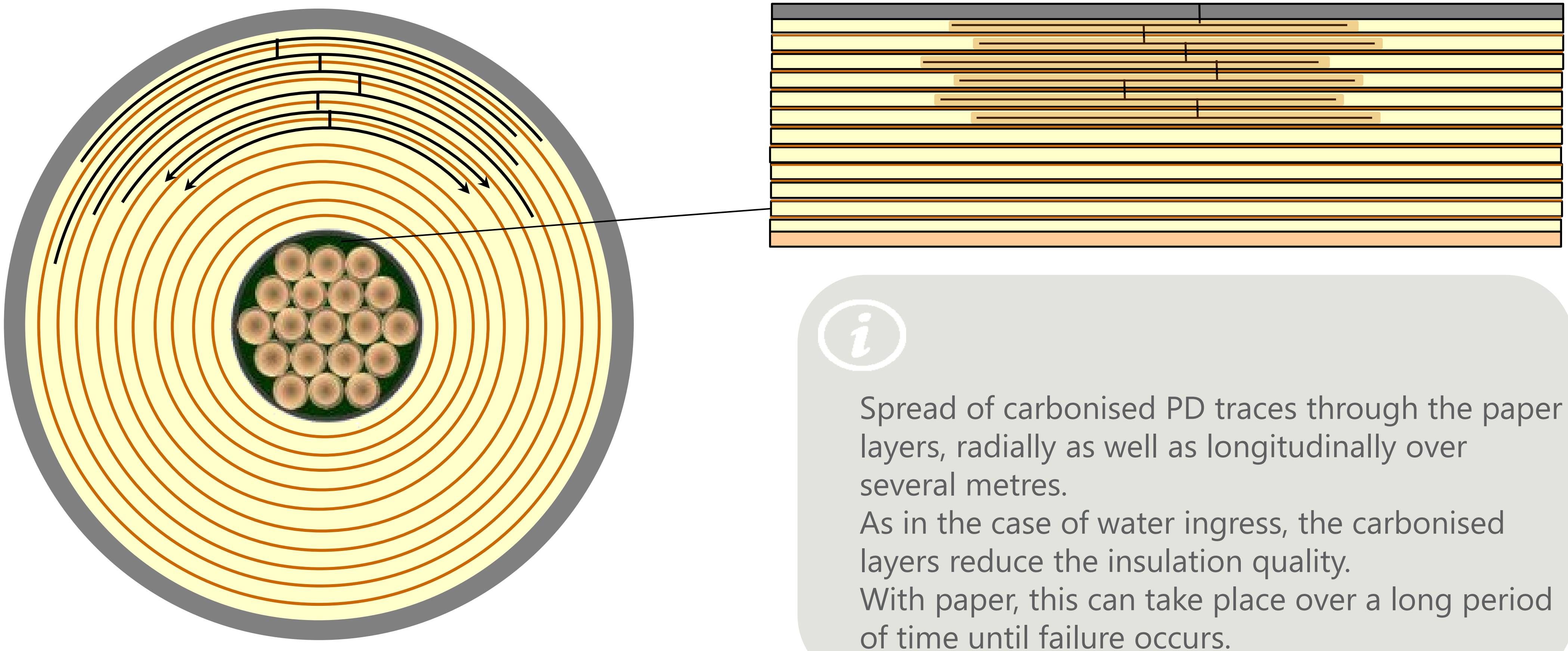
Voiding due to loss of oil



Due to the "disappearance" of the oil in certain places, the cable dries out, the insulation quality deteriorates, PD starts, and breakdowns are caused. The "melted" oil that subsequently flows in leads to temporary self-healing.

Partial discharge (PD) in paper-insulated cables

Dried out insulation

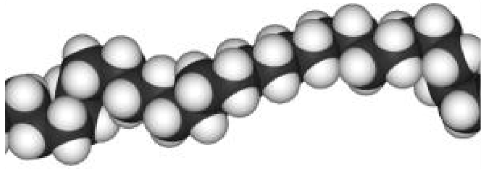


Spread of carbonised PD traces through the paper layers, radially as well as longitudinally over several metres.
As in the case of water ingress, the carbonised layers reduce the insulation quality.
With paper, this can take place over a long period of time until failure occurs.

XLPE/PE material

Cross-linked polyethylene (XLPE/PE)

- [CH2 – CH2]



- Very high dielectric strength
- Low transmission losses
- Outstanding dielectric properties
- Theoretical life expectancy > 50 years
- Allows a reduction in cable thickness
- Greater mechanical strength
- Higher operating temperature
- Easy and inexpensive to produce
- Easy processing and installation

Material

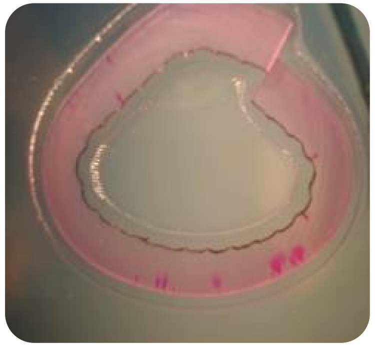
XLPE disadvantages

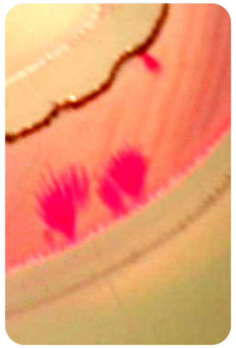
- Moisture encourages trees
- Sensitivity to HF/HV transients
- Requires correct handling
- First generation PE has just reached 20 years
- Testing with DC is pointless and harmful

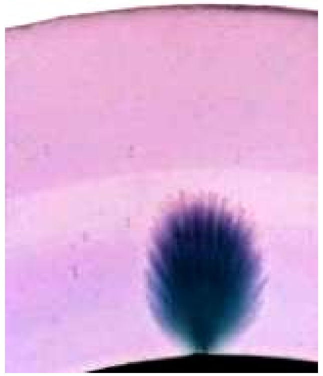
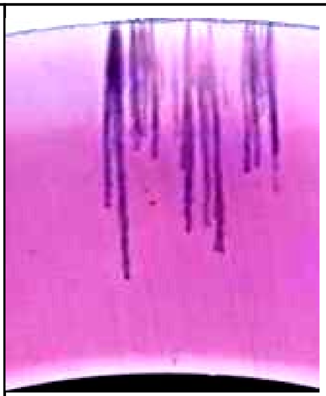
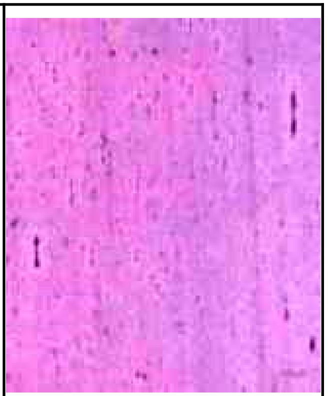
XLPE problems	Approach
Sheath faults/water ingress	Tan δ
Ageing/water trees	Tan δ
Impurities during production	PD + VLF
Mechanical damage	PD + VLF
Problems with joints	PD + VLF

Water trees

Water tree growth in XLPE insulation



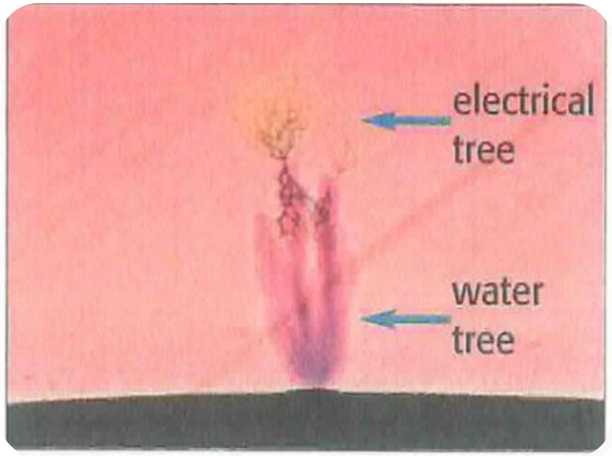


			
A) Cable S6, 21 years old	B) Cable S6, 21 years old	C) Cable S1, 17 years old	D) Cable S10, 11 years old

- Growth even at low field strength (< 1 kV/mm)
- Very slow growth (15 - 20 years)
- No partial discharge
- No directly visible effects

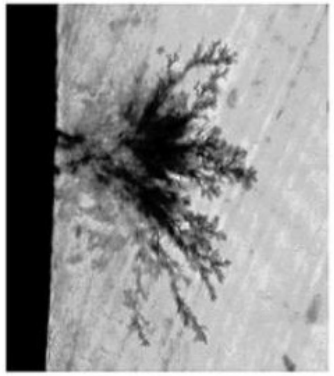
Water tree → electrical tree

The final stage of a water tree.
The water tree transforms into an electrical tree.

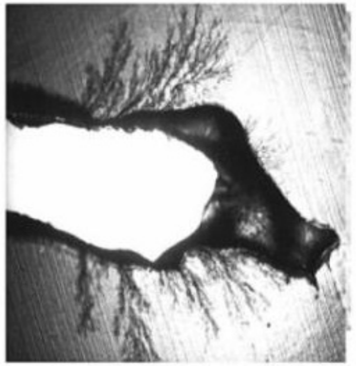


Water tree:
- No partial discharges
- Leakage currents

Electrical tree:
- Partial discharges
- Finale stage before breakdown


Water trees

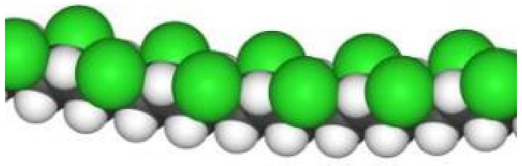

Electrical tree


Breakdown

PVC material

PVC cable

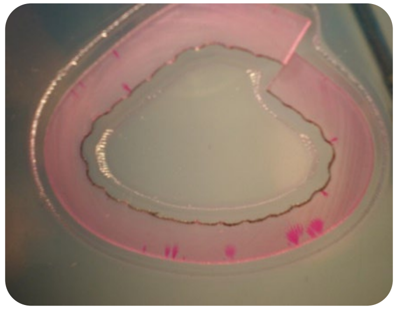
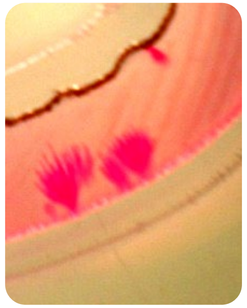
$- [\,CH_2 - CH\,] -$
|
Cl



- Predominantly used in LV installations
- Inexpensive
- Flexible
- Tolerates high temperatures
- High life expectancy
- Electrical trees are not critical
- Sometimes also used in MV systems
- High dielectric losses

Why do faults occur in the first place?

Cable ageing
- Water trees
- Natural ageing

Overload
- Increased energy consumption
- Wrong decision

"Natural enemy"
- Construction machinery
- Environmental influences

Type of cable fault

Insulation resistance measurement

- **Low-resistive (R < 100 Ω) ISO**
  Short-circuit (R < 10 Ω)

- **High-resistive (R > 10 Ω) ISO**
  Resistance faults
  Breaks

- **High-resistive (R > ∞ Ω) DC breakdown detection**
  Voltage-dependent faults
  (breakdown faults)

- **Earth faults – Leakage current due to sheath testing**
  Sheath faults
  Earth faults

Faults between phase-phase or phase-screen

Defects in the outer sheath (PVC, PE)
Screen or phase has contact with earth

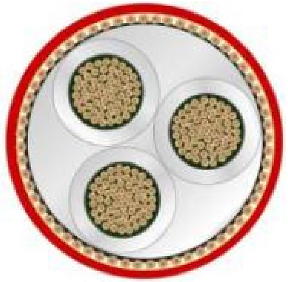
Type of cable fault

Breakdown detection

Determination of the breakdown voltage between the phase and screen

- Phase 1 – Neutral
- Phase 2 – Neutral
- Phase 3 – Neutral
- Phase 1 – Phase 2
- Phase 2 – Phase 3
- Phase 3 – Phase 1

Breakdown testing is only performed between the core and screen! Exception: belted cables



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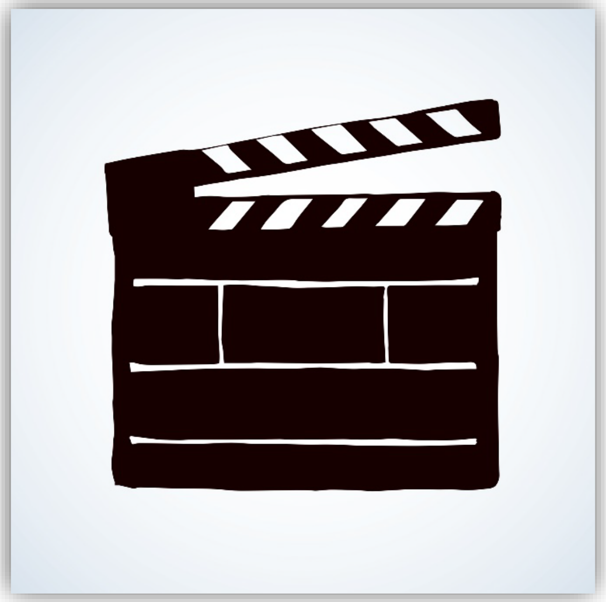
Sheath testing

Voltage test on the sheath		
Test voltage	**Test level**	**Test duration**
DC for cables according to VDE 0276 Part 620 HD 620 S2:2010, parts 0, 1, 10-C Extruded cables 10 - 30 kV	PVC sheath 3 kV PE sheath 5 kV	1 min
DC for cables according to VDE 0276 Part 632 HD 632 S1 parts 1, 3D, 4D, 5D Extruded cables 36 - 150 kV	5 kV	1 min

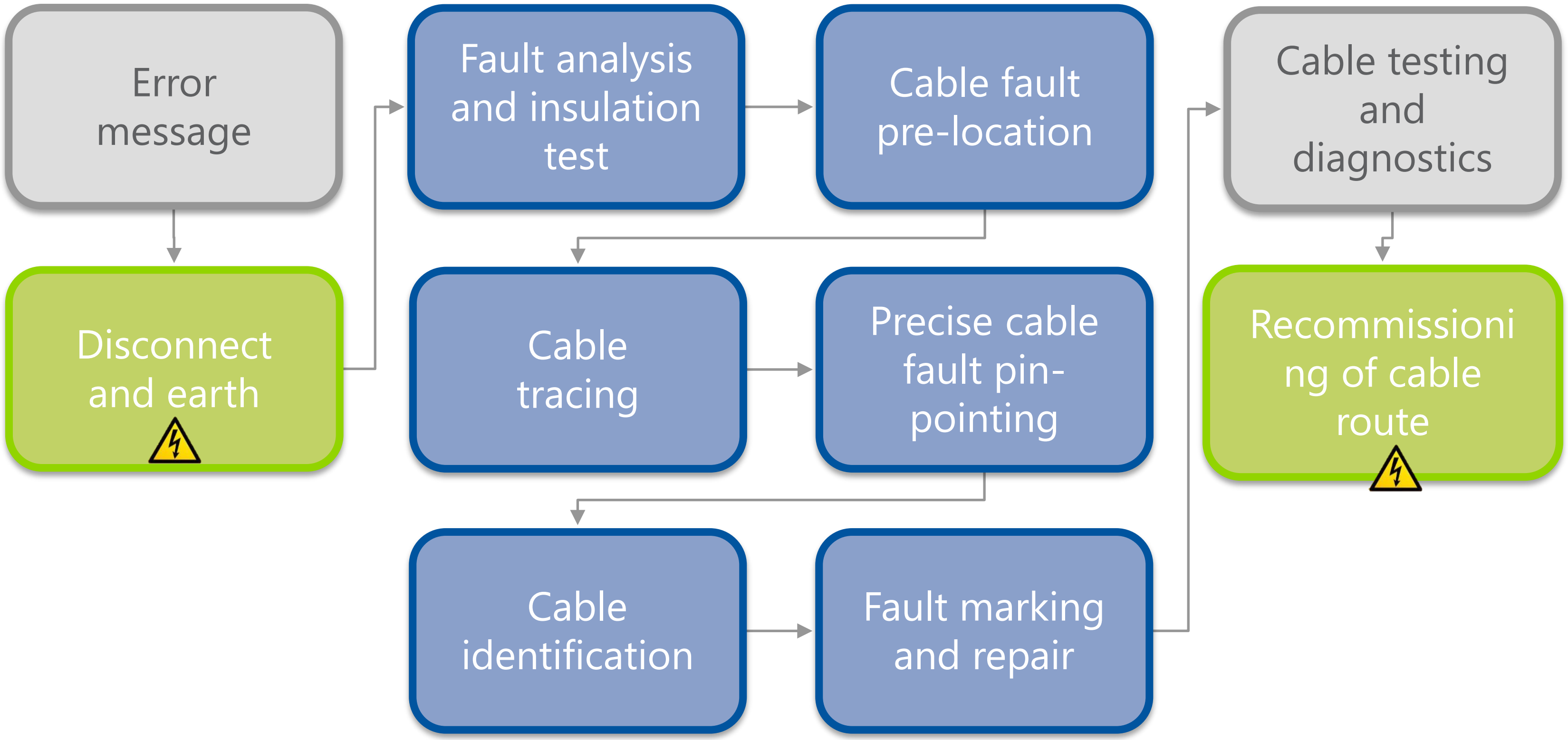
Cable fault location

titron® video



Sequence – cable fault location

Cable fault location sequence

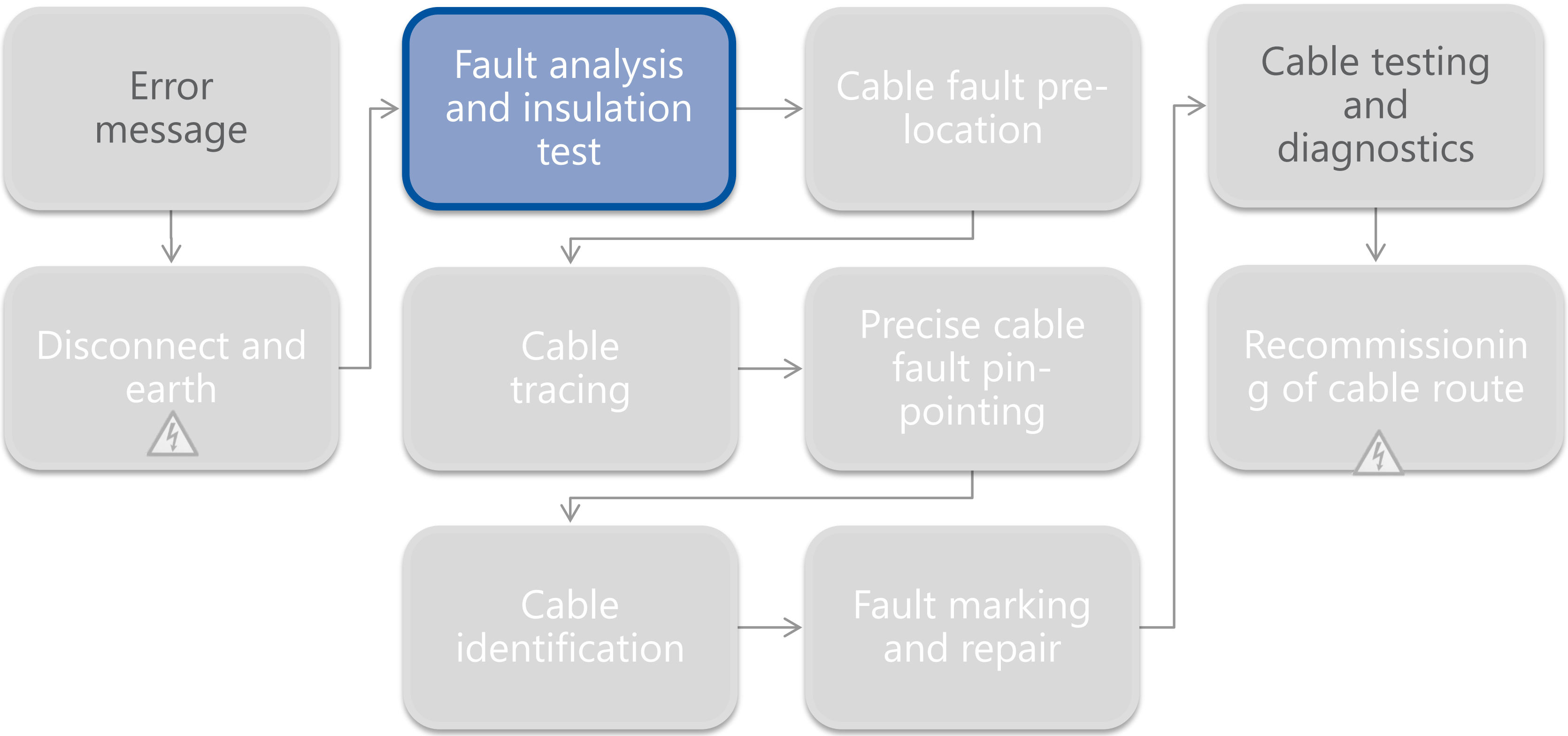


= Subprocess

= Safety procedure (in accordance with local standards and safety regulations)

= Cable fault location process

Fault analysis and insulation test



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Fault analysis

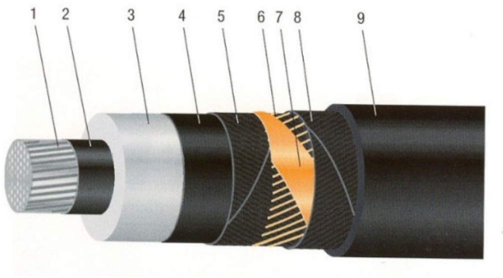
Measurement of insulation resistance

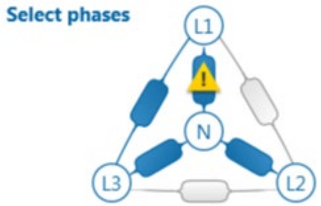
Fault analysis

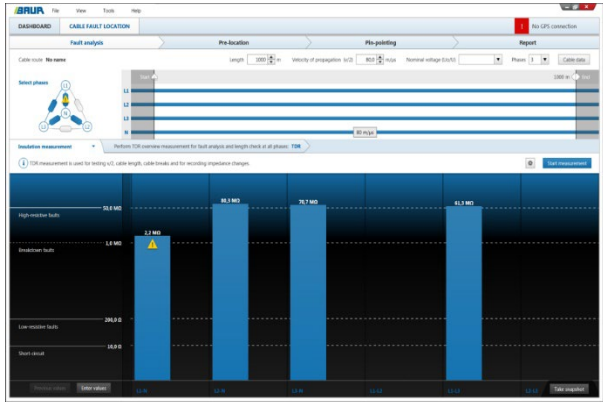
- Measurement of phase - screen
- Measurement of phase - phase
- Phase - ground

Determination

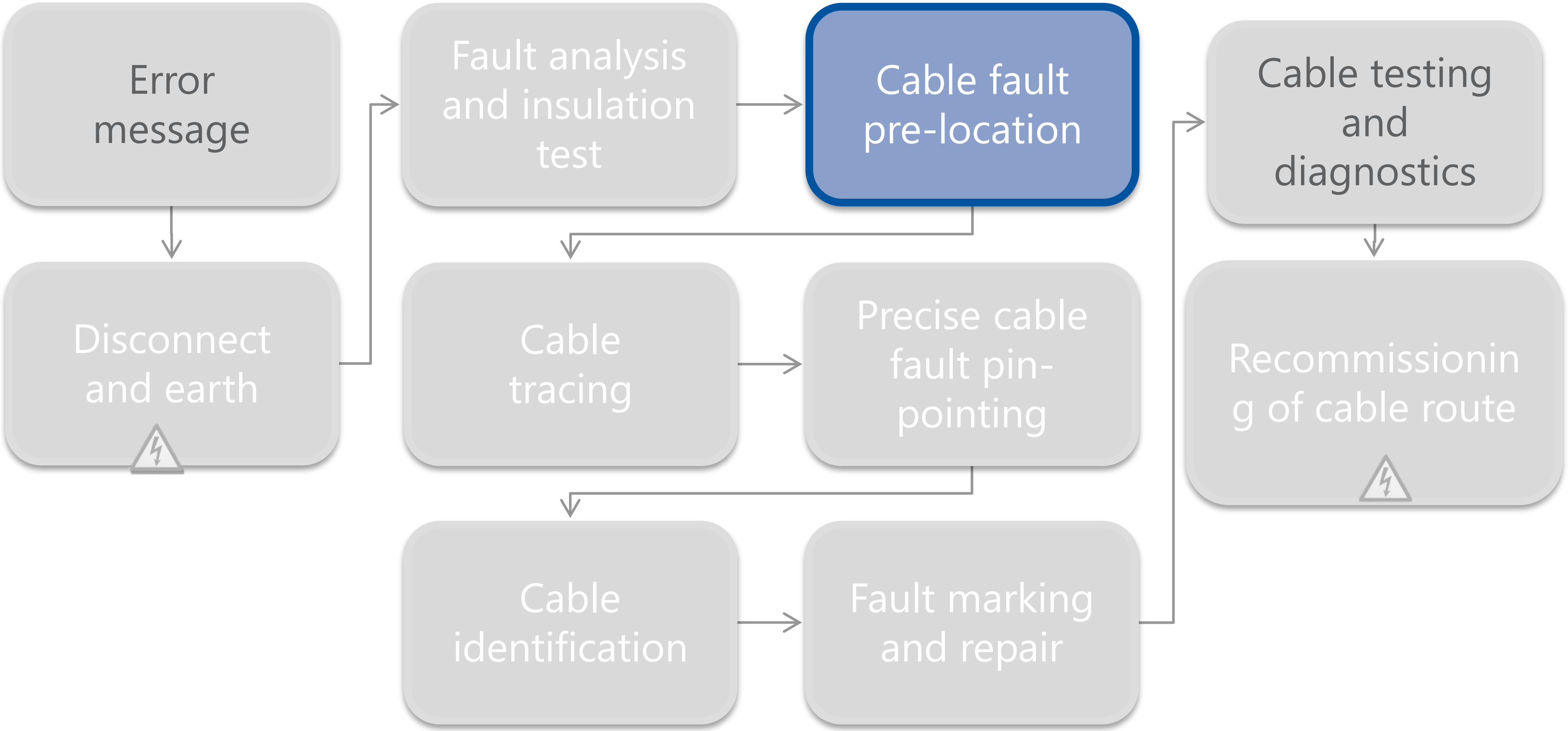
- Which phase is affected?
- What type of fault?
- Which pre-location method?







Cable fault pre-location

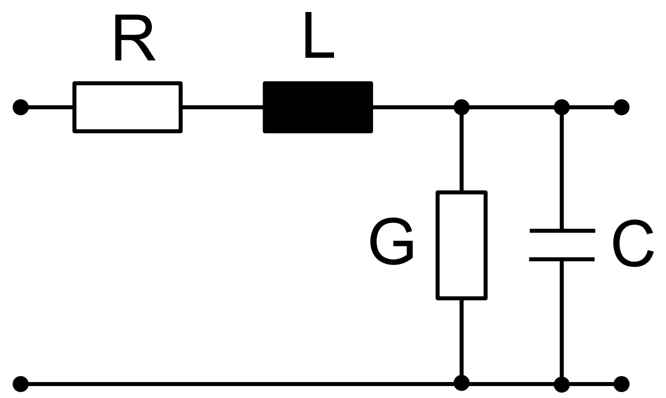


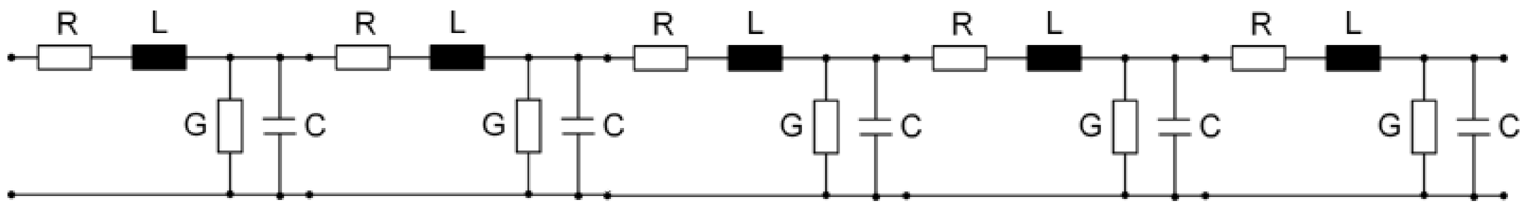
Methods

Method	**Fault characteristics**
Time Domain Reflectometry (**TDR**)	Low-resistive faults, breaks
Secondary/multiple impulse method (**SIM/MIM**)	High-resistive faults, breakdown faults
Conditioning **SIM/MIM**	High-resistive faults, breakdown faults, "moist" faults
Burn	High-resistive faults, "moist" faults
Current coupling method (**ICM**)	High-resistive faults, breakdown faults (predominantly for long cable routes)
Travelling wave method/**decay** method	Voltage-ignited faults – if high voltage is required
3-phase current coupling	For branched cable systems
Bridge measurement	Low- and high-resistive faults, cable sheath faults

The electrical equivalent circuit diagram

The cable is made up of an infinite number of small cable elements
R – series resistance
L – series inductance
G – parallel resistance
C – parallel capacitance





C = capacitance per unit length in nF per km
G = conductance per unit length in ohms per km
L = inductance per unit length in mH per km
R = resistance per unit length in ohms per km **(loop resistance)**

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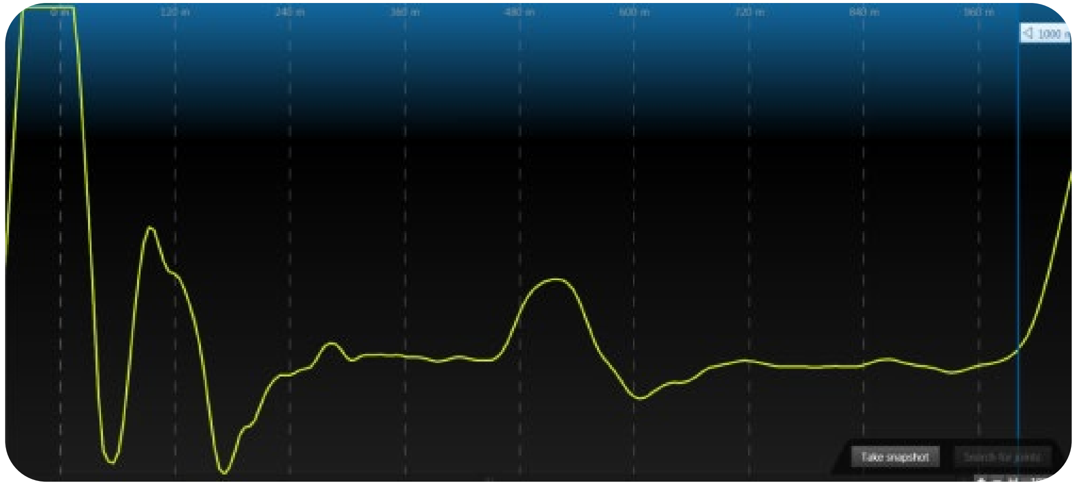
Functional principle of TDR

The transmitted TDR pulse runs along the cable route.
Each impedance change reflects parts of the pulse back to the starting point,
where the pulses are recorded.
The time intervals of these reflections are converted into a distance.
The form of the reflection provides information about the type of impedance change and therefore the fault.



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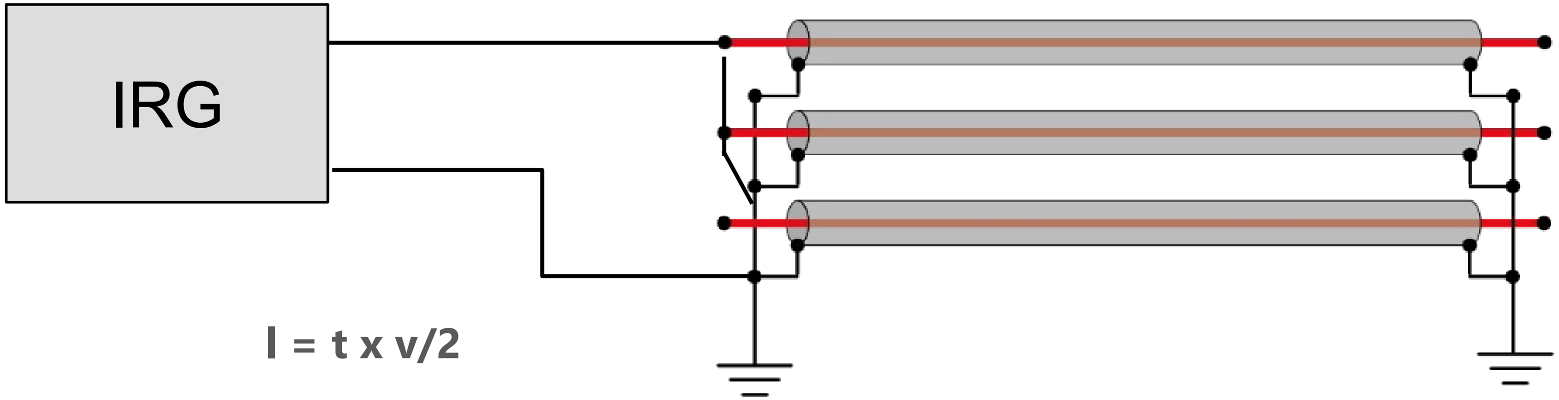
Time Domain Reflectometry (TDR)



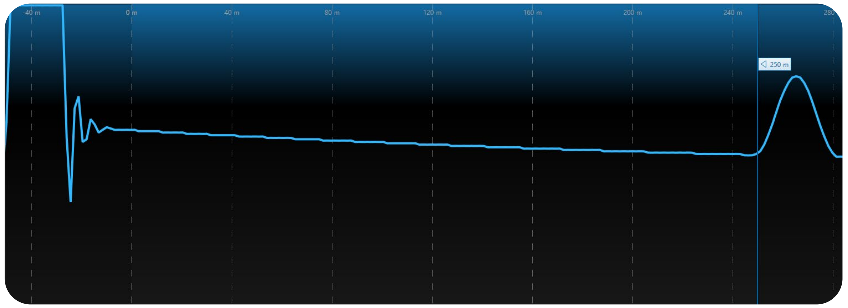
l = t x v/2

High Ω, open end

Low Ω, short-circuit fault

Impedance change, e.g. joint

l = t x v/2



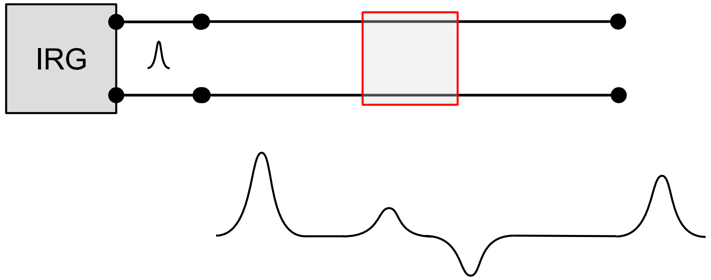
Reflection factor $r = \frac{Z_2 - Z_1}{Z_2 + Z_1}$

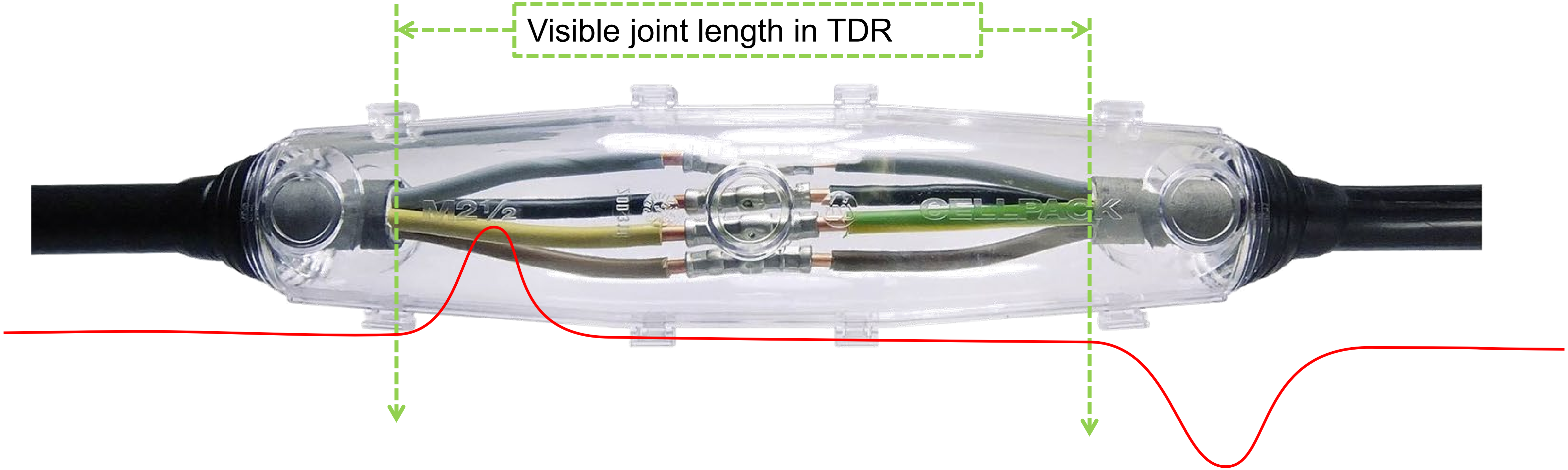
LV pulse max. 200 V

Time Domain Reflectometry (TDR)

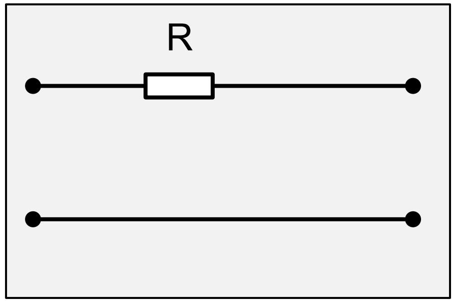
Joint reflection

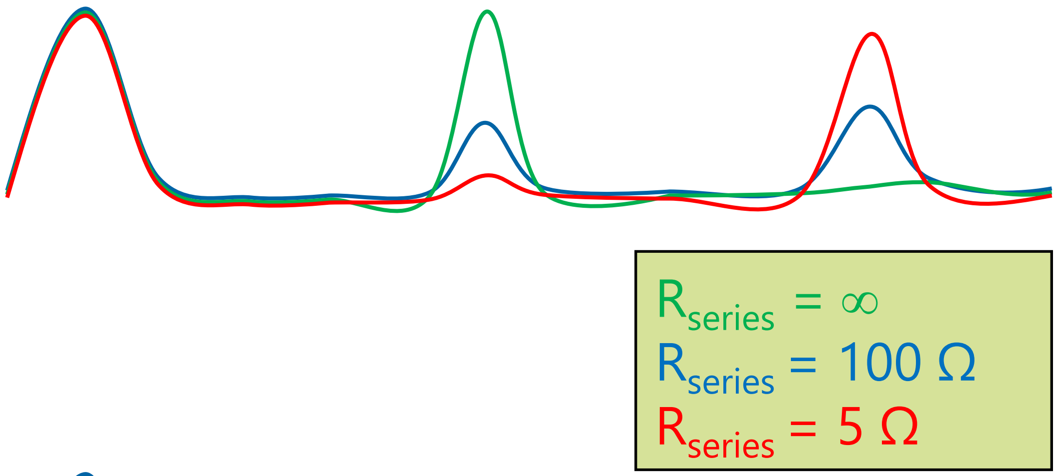
Joint



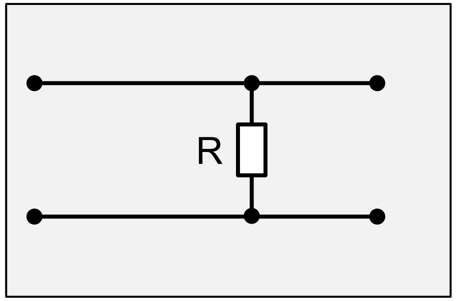


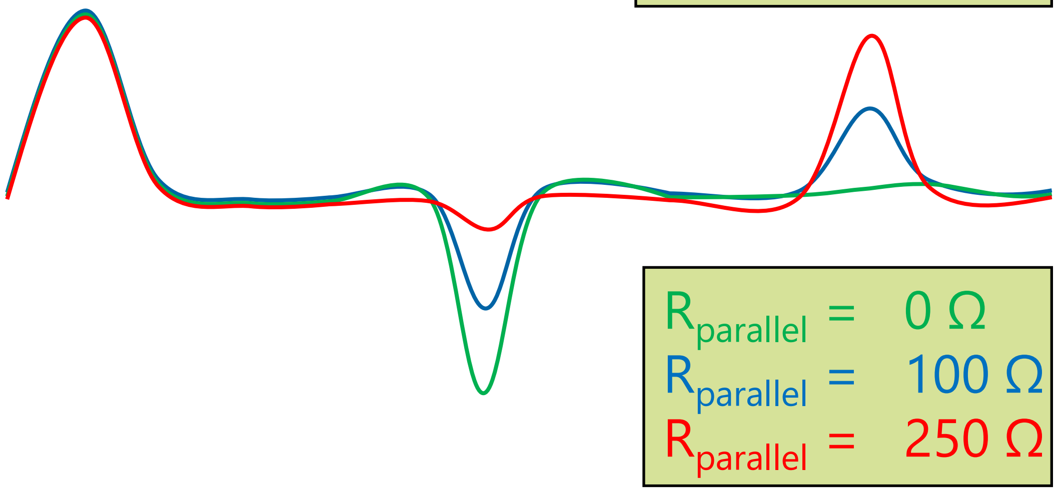
Influence of faulty resistors on the reflection image





Typical fault





Cable fault pre-location methods

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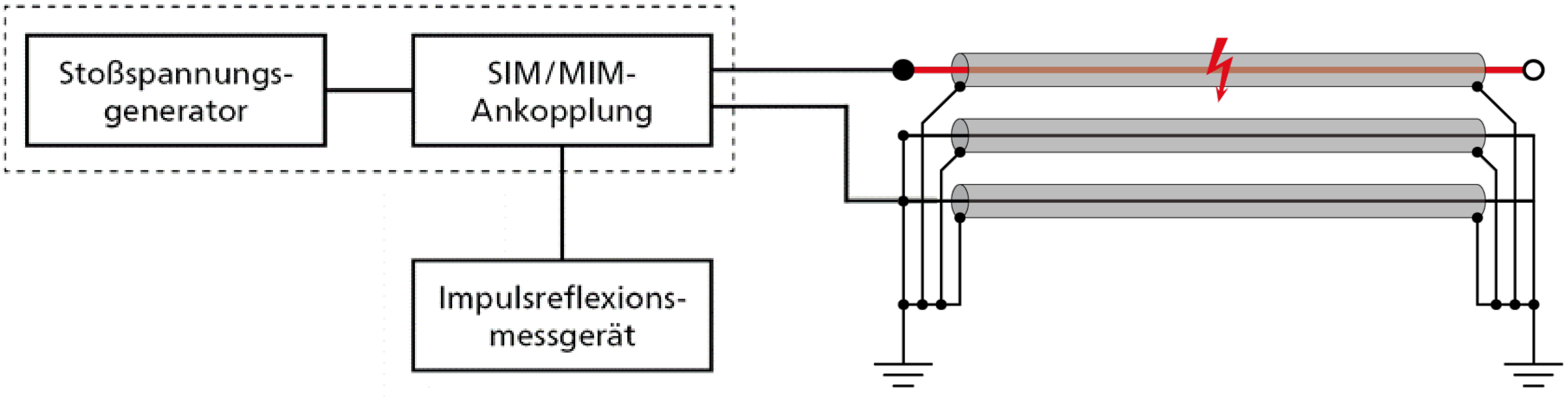
SIM/MIM – multiple impulse method

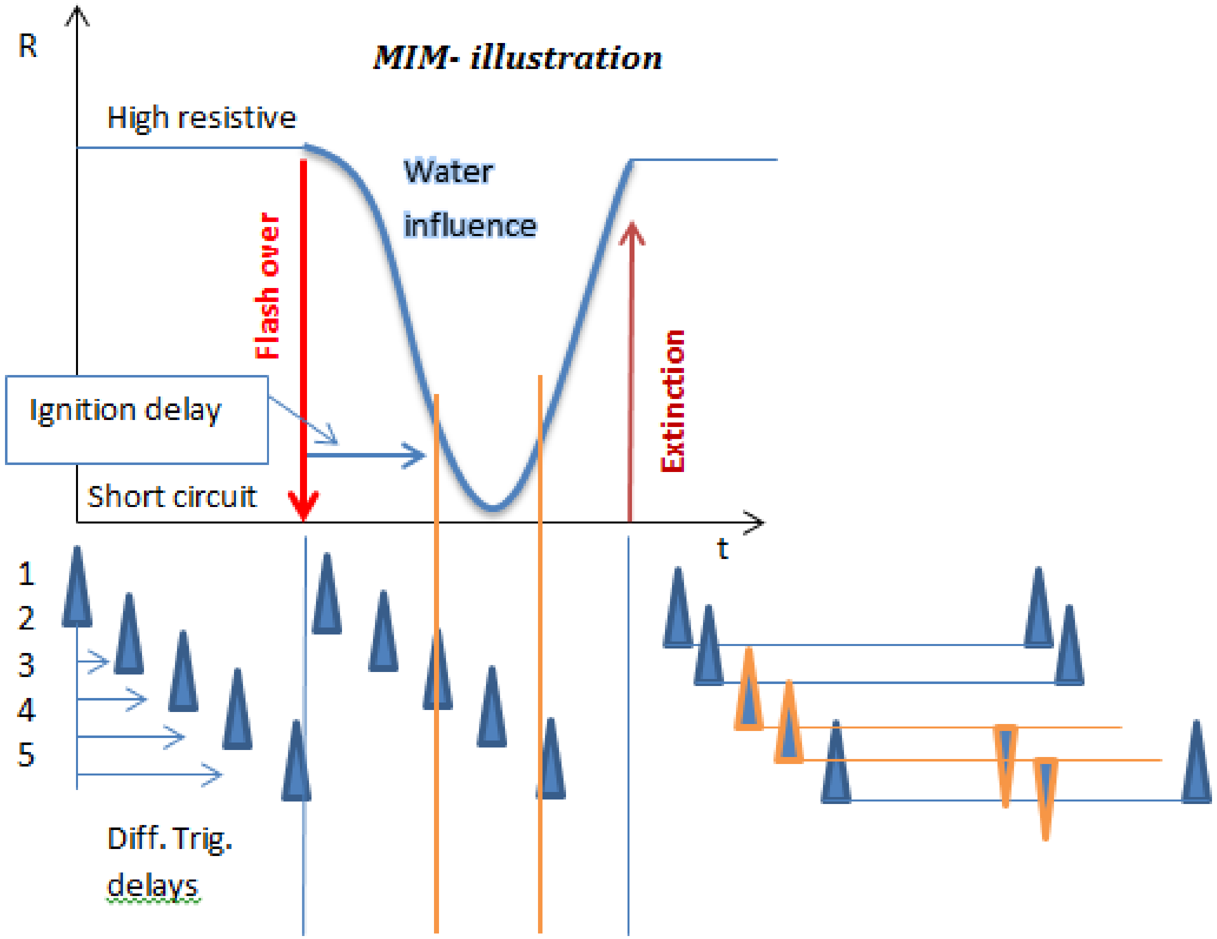
Combination of TDR and surge generator



l = t x v/2

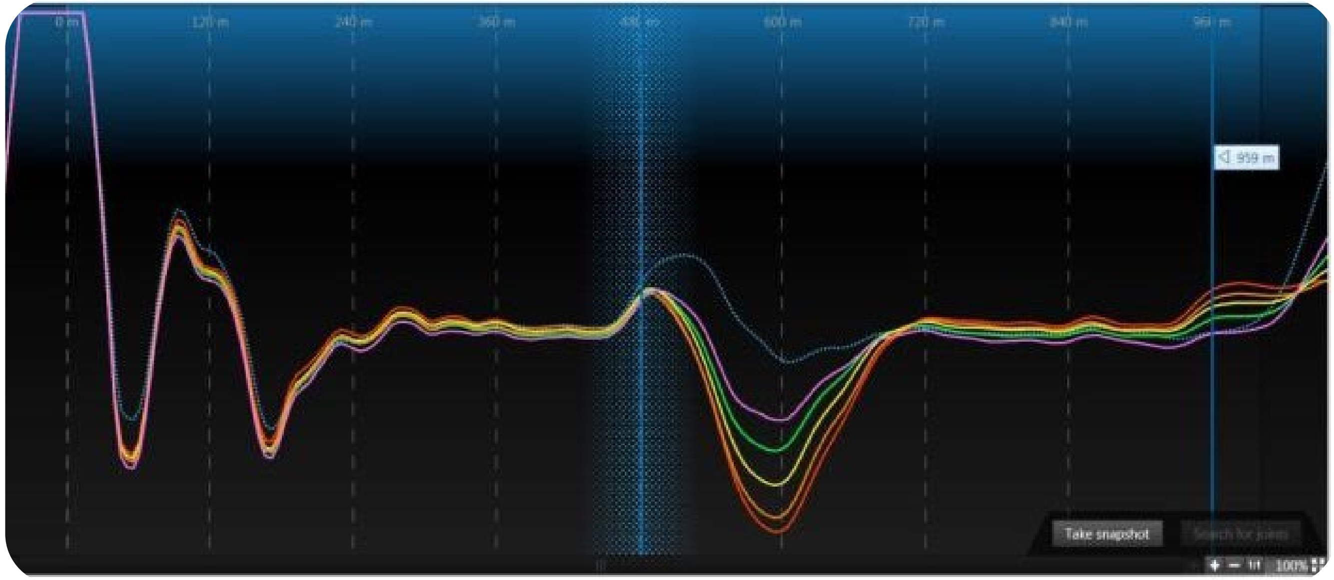
SIM/MIM – multiple impulse method

Combination of TDR and surge generator



SIM/MIM – multiple impulse method

Combination of TDR and surge generator



First measurement: Positive reflection at cable end

Second measurement: 20x negative reflection during breakdown at the fault location

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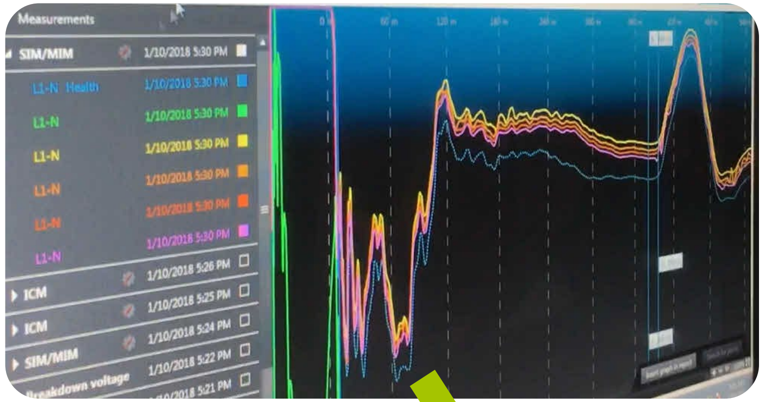
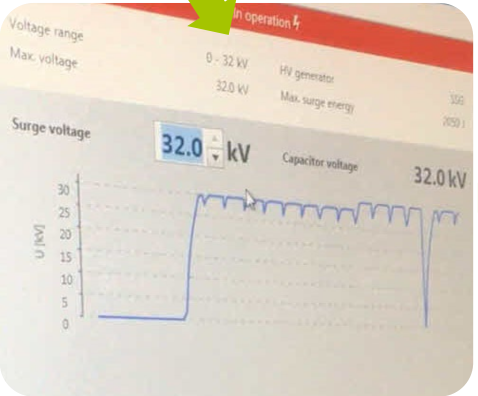
Conditioning SIM/MIM – application in the case of wet faults

Combination of surge conditioning and SIM/MIM

1. SIM/MIM result in wet joint state





2-4. Surge conditioning

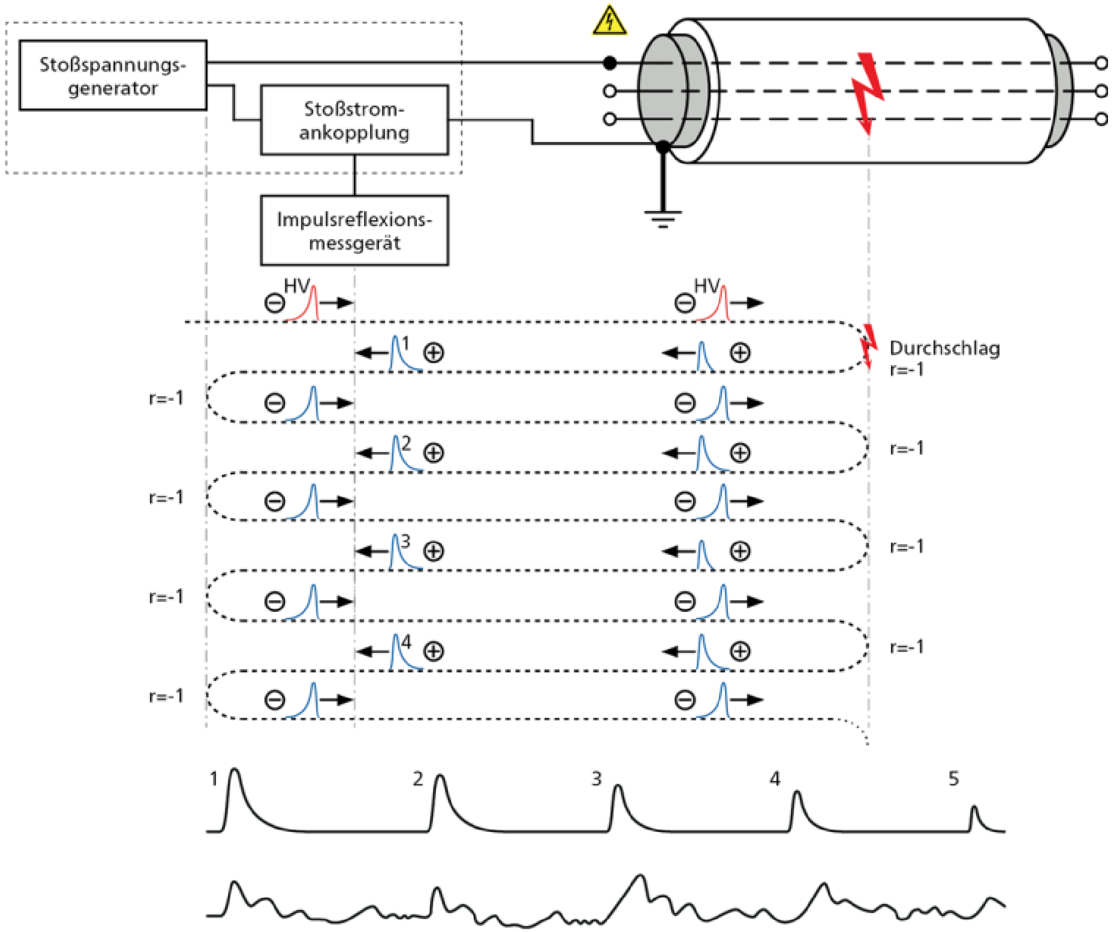
5. SIM/MIM result after drying the fault

Cable fault pre-location methods

Method	Fault characteristics
Time Domain Reflectometry (**TDR**)	Low-resistive faults, breaks
Secondary/multiple impulse method (**SIM/MIM**)	High-resistive faults, breakdown faults
Conditioning **SIM/MIM**	High-resistive faults, breakdown faults, "moist" faults
Burn	High-resistive faults, "moist" faults
Current coupling method (**ICM**)	High-resistive faults, breakdown faults (predominantly for long cable routes)
Travelling wave method/**decay** method	Voltage-ignited faults – if high voltage is required
3-phase current coupling	For branched cable systems
Bridge measurement	Low- and high-resistive faults, cable sheath faults

Current coupling method (ICM)

D = L - test lead



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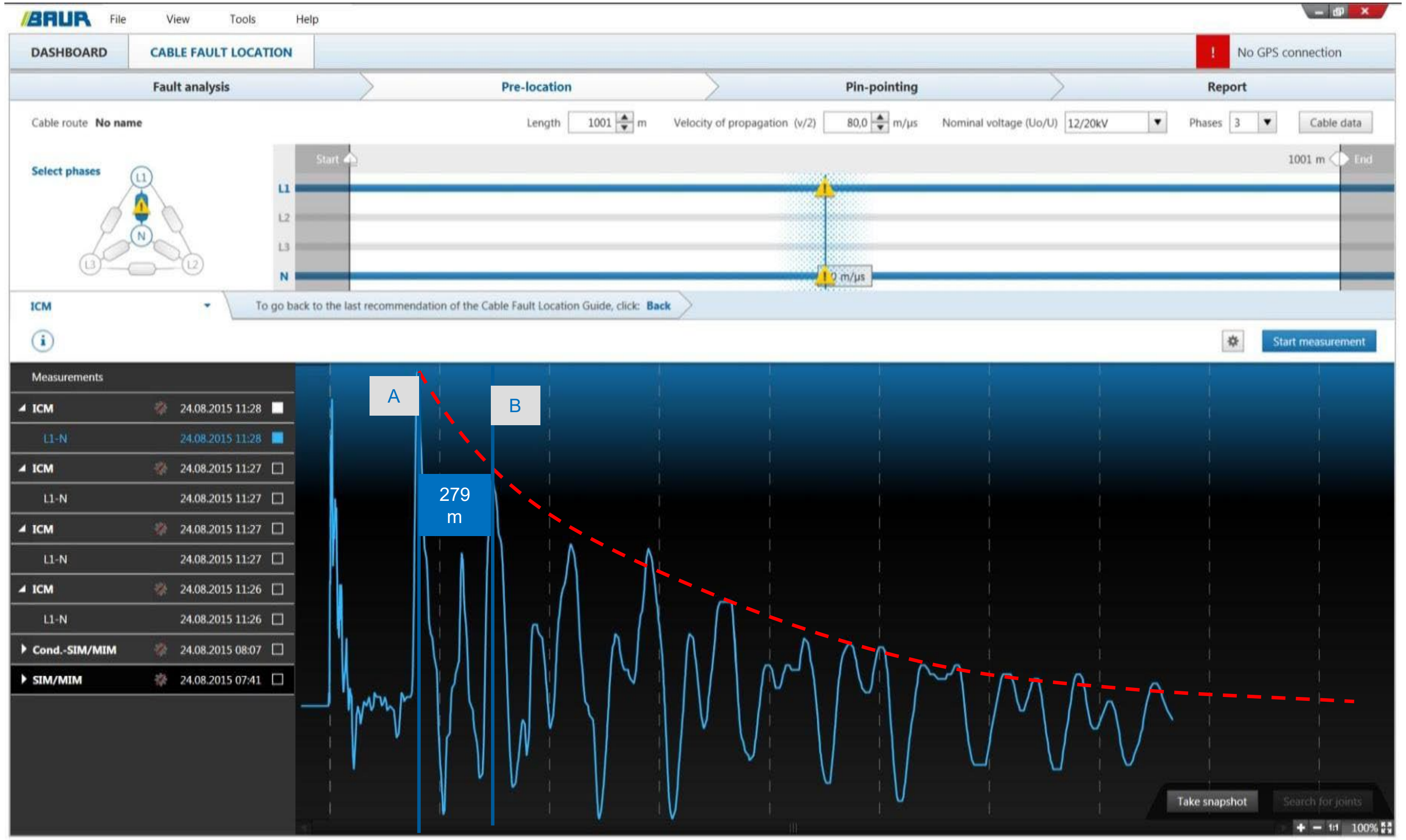
Current coupling method (ICM)



Cable fault pre-location methods

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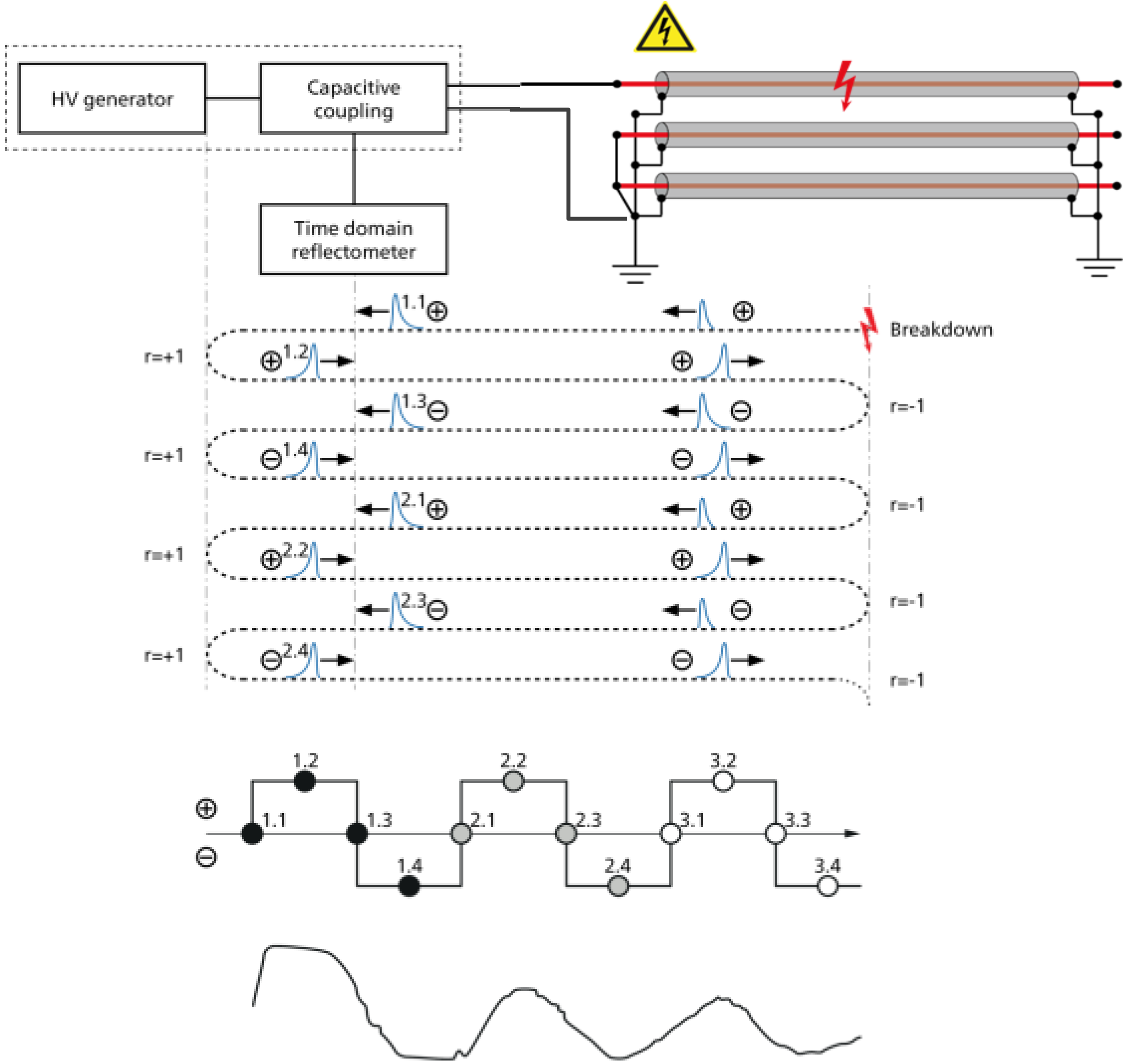
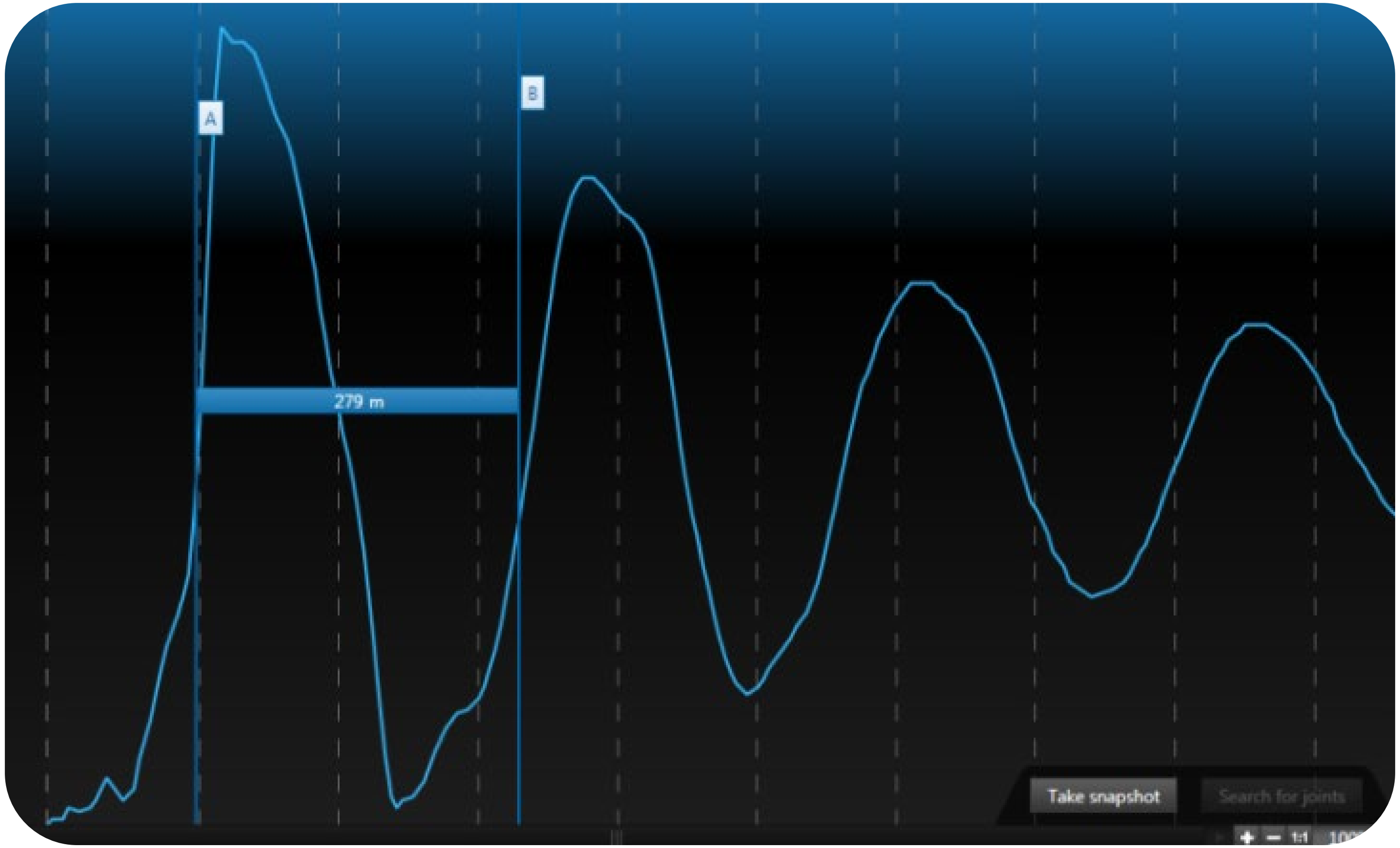
"Travelling wave method/decay method"

$$D = \frac{L}{2} \text{ - test lead}$$



Decay method



Comparison

SIM/MIM

- Most widely used HV fault location method
- Many details are visible (joints, cable end, etc.)
- Max. SSG voltage (typically 32 kV)
- Set measurement range to single cable length
- Connection cable length is automatically subtracted

ICM current coupling

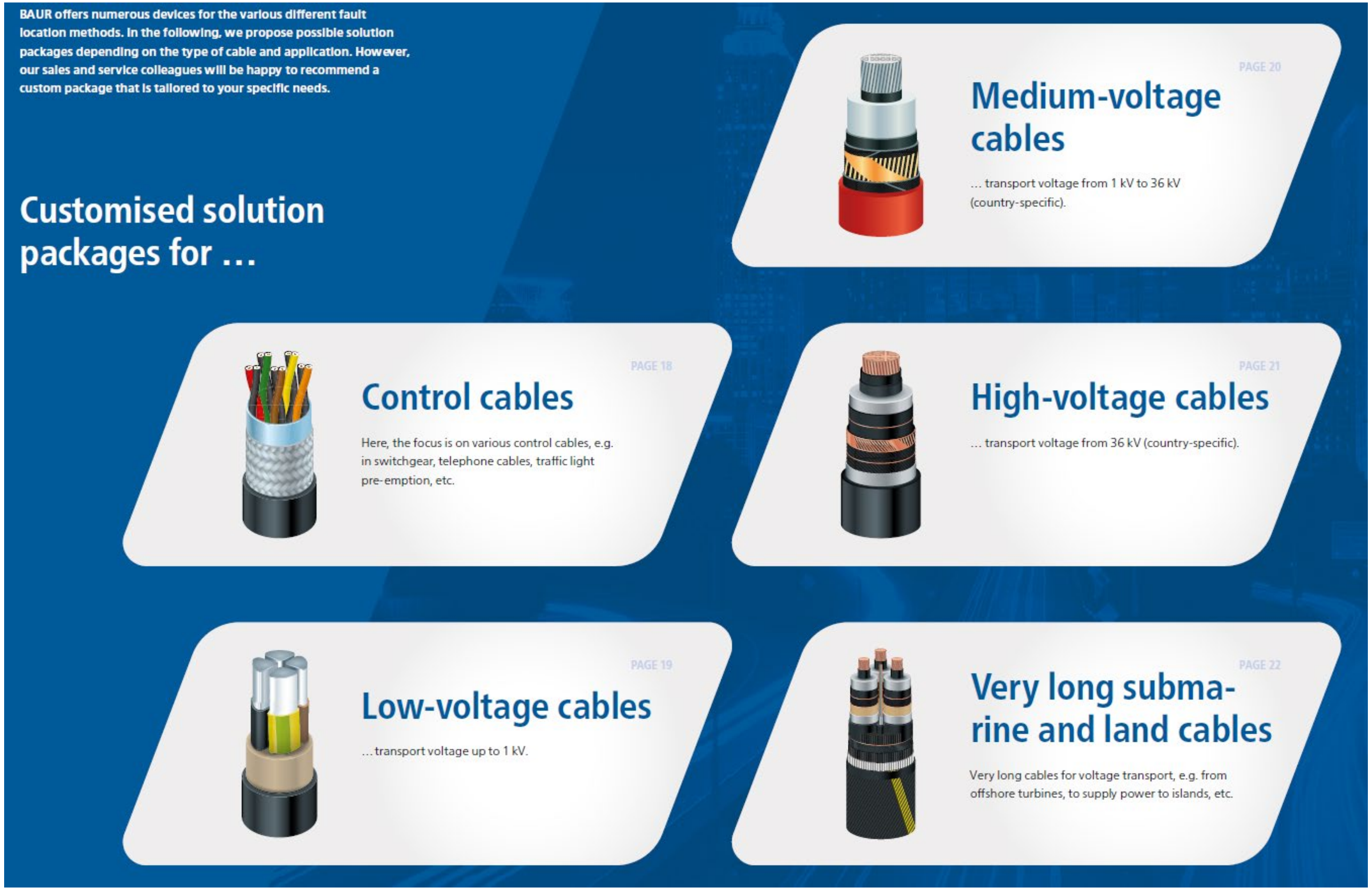
- For long cables and faults in wet joints
- Max. SSG voltage (typically 32 kV)
- Measurement range is set to 5 to 10 times the cable length
- Increase gain
- Measure the length of a period
- First period is not used for the measurement ("ignition lag")
- Measured length is 7 to 15% too far due to varying v/2
- Connection cable length must be subtracted

Decay

- For cable faults where a high HV voltage is required
- It must be possible to load the faulty cable, and then produce a breakdown. Faults with leakage currents cannot be located.
- Measurement range is set to 5 to 10 times the cable length
- Reduce gain
- Measure the length of a period and divide by 2
- Connection cable length must be subtracted

What solutions does BAUR offer?

BAUR – solutions



BAUR offers numerous devices for the various different fault location methods. In the following, we propose possible solution packages depending on the type of cable and application. However, our sales and service colleagues will be happy to recommend a custom package that is tailored to your specific needs.

Customised solution packages for …

PAGE 20

Medium-voltage cables

… transport voltage from 1 kV to 36 kV (country-specific).

PAGE 18

Control cables

Here, the focus is on various control cables, e.g. in switchgear, telephone cables, traffic light pre-emption, etc.

PAGE 21

High-voltage cables

… transport voltage from 36 kV (country-specific).

PAGE 19

Low-voltage cables

… transport voltage up to 1 kV.

PAGE 22

Very long submarine and land cables

Very long cables for voltage transport, e.g. from offshore turbines, to supply power to islands, etc.

Cable fault location systems – solutions

Low- and medium-voltage cables

- Cable fault pre-location
- Cable fault pin-pointing
- Sheath fault/earth fault pre-location
- Sheath fault/earth fault pin-pointing
- Sheath testing

- Syscompact 400/4000 systems
- shirla
- protrac®

Cable fault location systems – solutions

Portable system solutions

Syscompact 400 portable

Standard Solution

- 10 m connection cable permanently mounted

Syscompact 400 portable

Customer-specific solution

- Incl. surge capacitor, 4 kV for LV application

Syscompact 400 portable

Customer-specific solution

- Coaxial HV connection socket
- 25 m/50 m cables on portable drums

Cable test vans

→ Combination of fault location/VLF testing and diagnostics

titron®, transcable 4000

- Various control systems available

- transcable 4000
  - Semi-automatic system, 1-phase/3-phase
  - Automatic system, 3-phase

Fault location systems and solutions

Low-, medium-, and high-voltage network cable fault location vans

Reference: TNB Malaysia

Syscompact series fault location systems

- **Mounted in local vehicles**
  - ✓54 systems delivered in 1994
  - ✓17 systems delivered in 2005
  - ✓15 systems delivered in 2010

- **Portable fault location systems**
  - ✓26 systems delivered in 2012
  - ✓7 systems delivered in 2013
  - ✓5 systems delivered in 2022

Reference: SESB Sabah/East Malaysia

Fault location systems mounted in local vehicles

- ✓24 systems delivered in 2011
- ✓1 portable system delivered in 2013
- ✓25 systems delivered in 2015




Reference: SEC Saudi Arabia

Syscompact 3000 fault location systems

✓30 systems delivered in 2016

Fault location systems incl. VLF test systems

✓5 systems delivered in 2017

Riyadh City Administration Saudi Arabia

Syscompact 3000 fault location systems

✓10 systems delivered in 2017




Reference: Shangdong Power Grid China

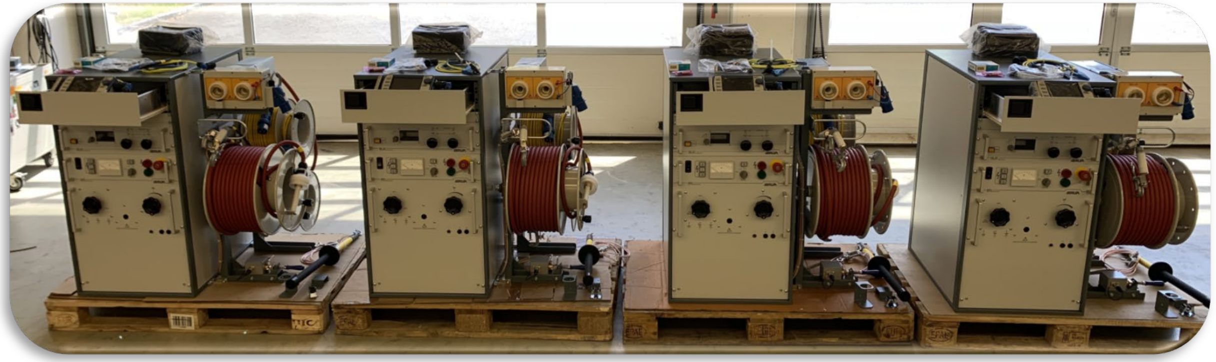
Syscompact 2000 fault location systems

✓17 systems delivered in 2020

Reference: Zimbabwe Electricity Distribution Co.

Syscompact 2000 fault location systems

✓9 systems delivered in 2022



Reference: KEPCO Korea

Syscompact 4000 fault location + VLF system

✓15 systems delivered in 2009 and 2015

✓8 systems upgraded in 2022

Reference: Shenzhen Power Grid

Cable fault location system – fully automatic single phase system

✓9 systems delivered in 2022 - 2023

Reference: Enel SpA

Cable fault location system – fully automatic 3 phases system + VLF

✓6 systems delivered in 2022

Reference: Adani Mumbai

Cable fault location system – fully automatic single phase system + VLF + TD PD

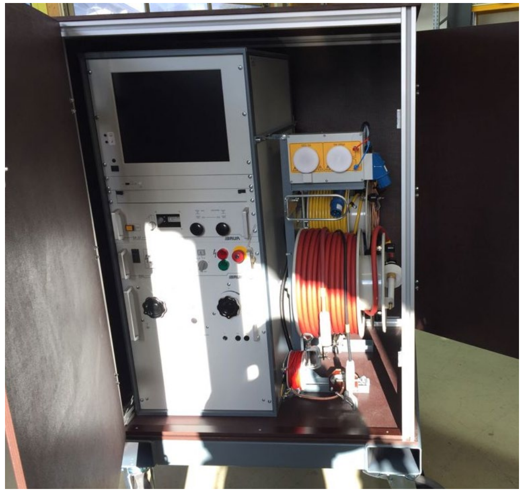
✓5 systems delivered in 2018-2022

Reference: Enel SpA

Cable fault location system – fully automatic 3 phases system + VLF

✓6 systems delivered in 2022

Reference: Terna Italy



Fault location systems

- **Mounted in local vehicles**
  - ✓8 systems delivered in 2021

XL fault location systems

- **Mounted in container**
  - ✓6 systems delivered in 2020

Cable test van

- Combination of fault location/VLF testing and diagnostics

- titron® fully automatic system
  - ✓Compact version
  - ✓1-phase
  - ✓3-phase

The new titron®

- Ergonomic, practical and comfortable – the unit
- Heavy on features, light on its feet – the 3.5 tonner that punches above its weight
- Simpler operation at the tap of a key or click of a mouse – the software
- Rectify network faults more quickly – the Smart Cable Fault Location Guide
- Create a high level of transparency at a low cost – the diagnostics philosophy
- A single data chain from collection through to analysis – home of diagnostics

The new titron®

Ergonomic, practical and comfortable – the unit

Advantages

- Enlarged work area
- Office-like feeling – workspace optimised for measurement use

Features

Larger LED monitors

- 1 x 24"
- 1 x 19" or 2 x 19"

The new titron® in detail

Ergonomic, practical and comfortable – the unit

Advantages

- Comfortable and functional working environment
- Optimised workspace – even when the test van is on site for extended periods

Features

- Adjustable seat with storage space
- With optional backrest

The new IRG 400 19″

Different versions to operate the system

Operation with a
15.6″ notebook and
the BAUR Software 4

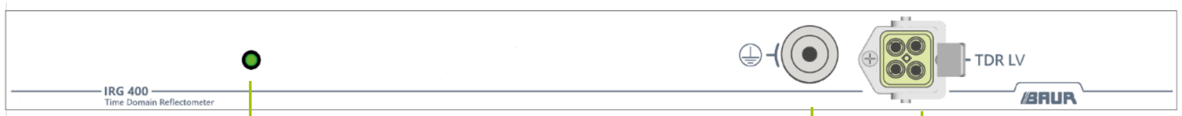
NEW: Operation with a
10.1″ tablet and our brand-new
touch operated BAUR App BUI-F

The new IRG 400 19″

- Measuring unit built in a 19″ system mounted blade
- Software controlled either via the approved BAUR IRG and system software 4 or completely new touch optimized BAUR App BUI-F
- The front end with a 10.1″ industrial rugged tablet or standard 15.6″ BAUR notebook
- Communications via Wi-Fi, allowing measurement from a convenient and safe position

The new IRG 400 19”

Key specifications



LED Communication indication

Earth Plug

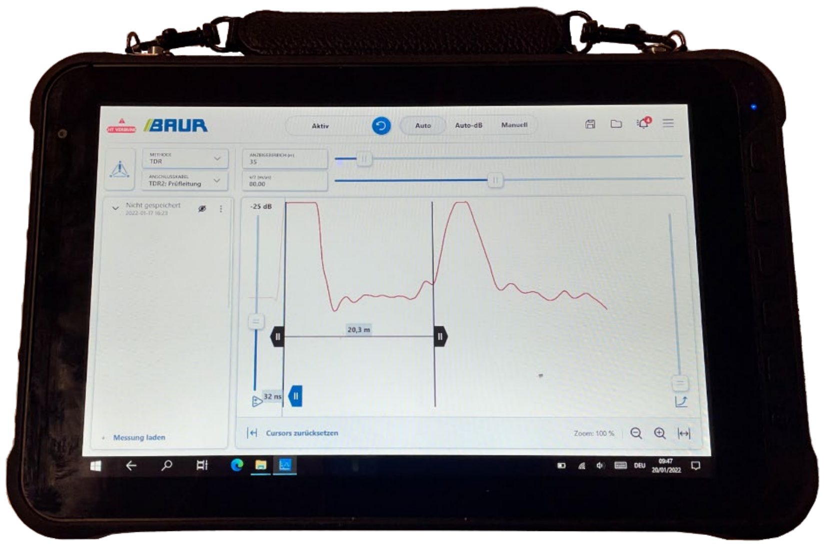
TDR-LV Output

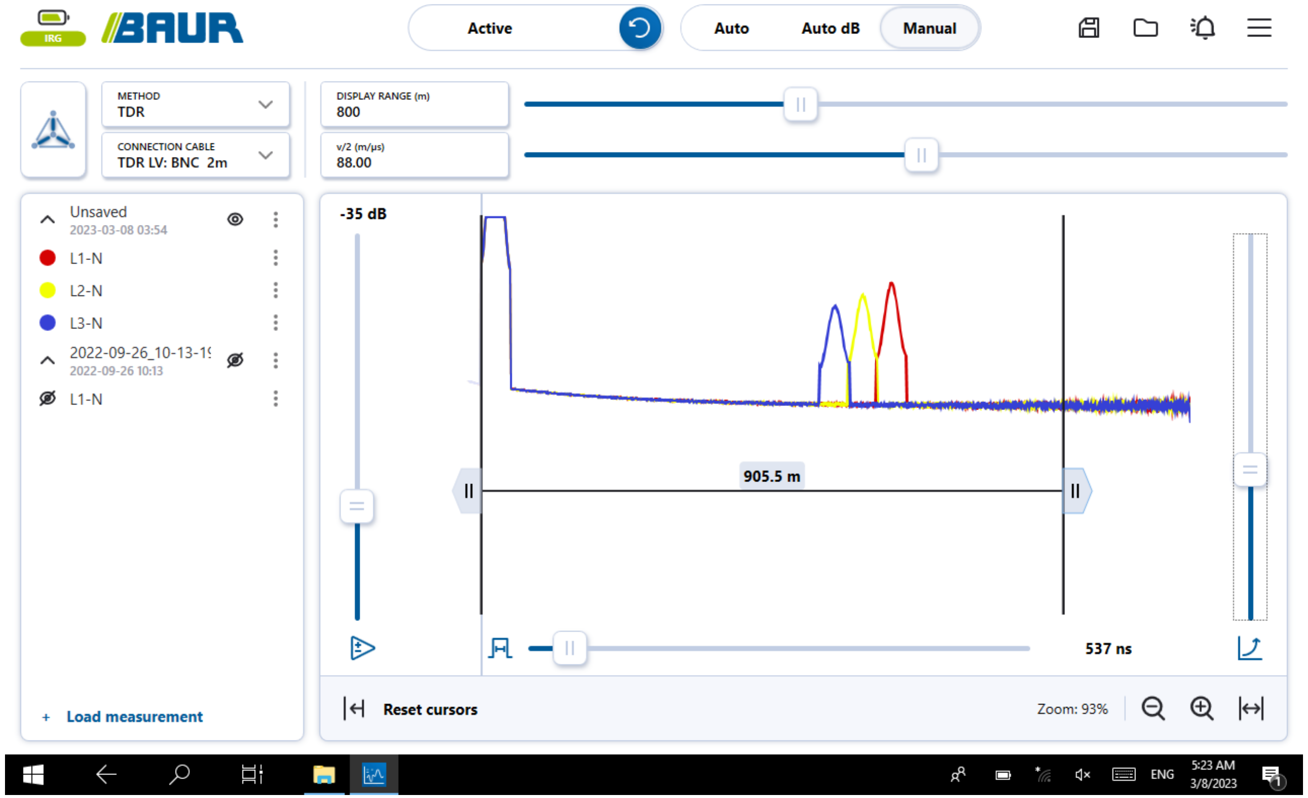
- **Touch operation**
- **Operation via Wi-Fi** by detachable notebook or tablet
- Large, bright **15.6” or 10.1” display**
- Support **of all Fault pre-location methods**
- Range de-attenuation
- Data
- **Sampling rate:** 400 MHz
- **Pulse width:** 30 ns -10 µs
- **Distance:** 10 m - 1000 km
- **Pulse amplitude:** max. 60 V
- **Dynamic range** 89 dB
- **Integrated Voltage Filter** CAT IV/600 V in combination with fused CAT IV/600 V test leads

The new BUI-F

Special features:

- Length related gain
- Touch operation
- Step TDR
- 3-phased TDR
- Win-10 tablet



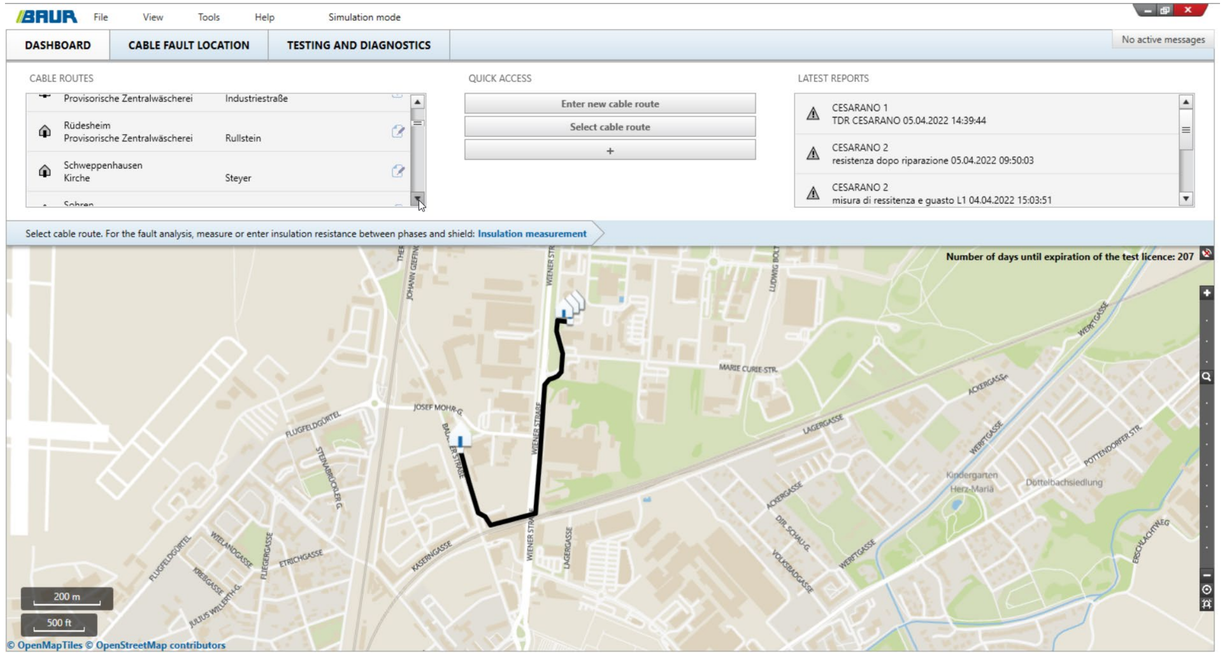


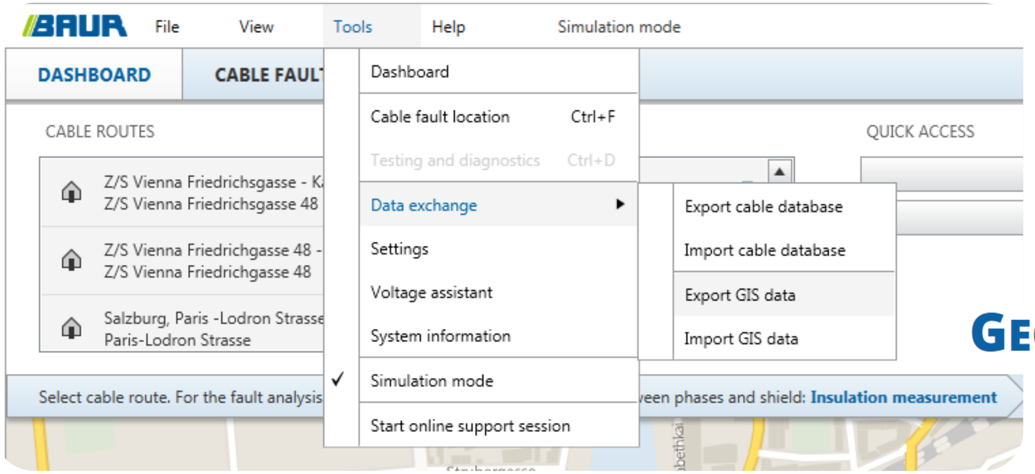
IRG 4000 integrated fault location software

Software functions

Open Street Map

Import/export of GIS cable data

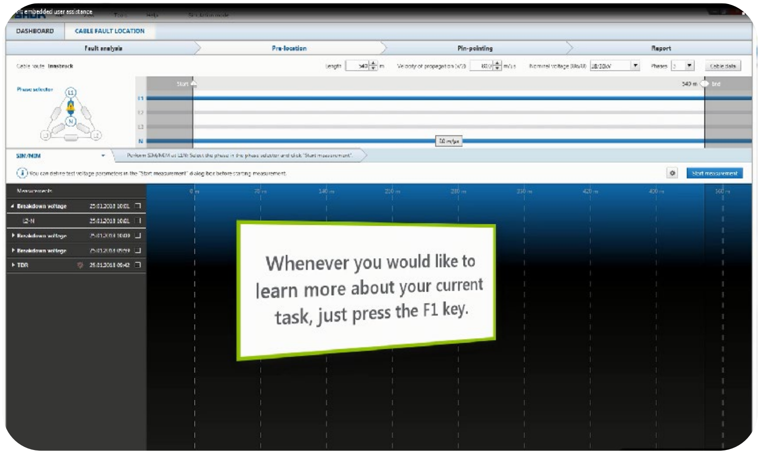


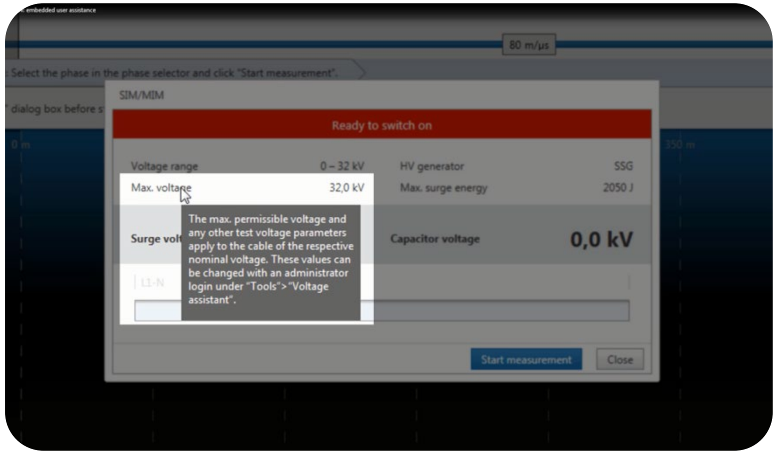


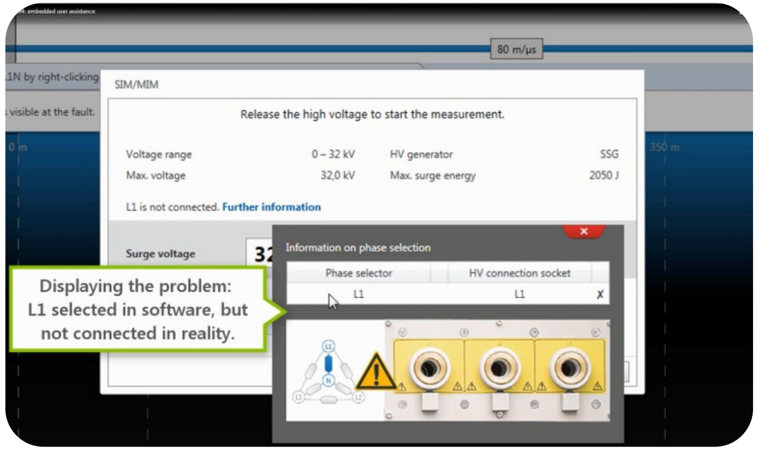
IRG 4000 integrated fault location software

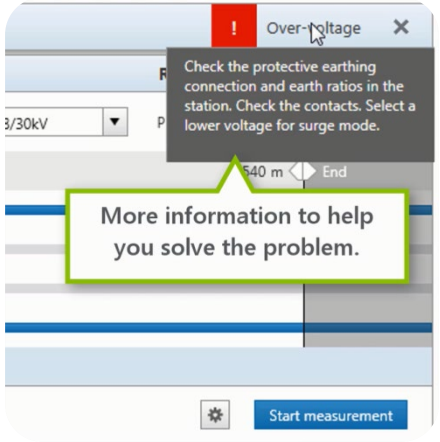
Interactive help menu

- F1 help menu
- Tool tip information menu
- Information for assistance at the current position









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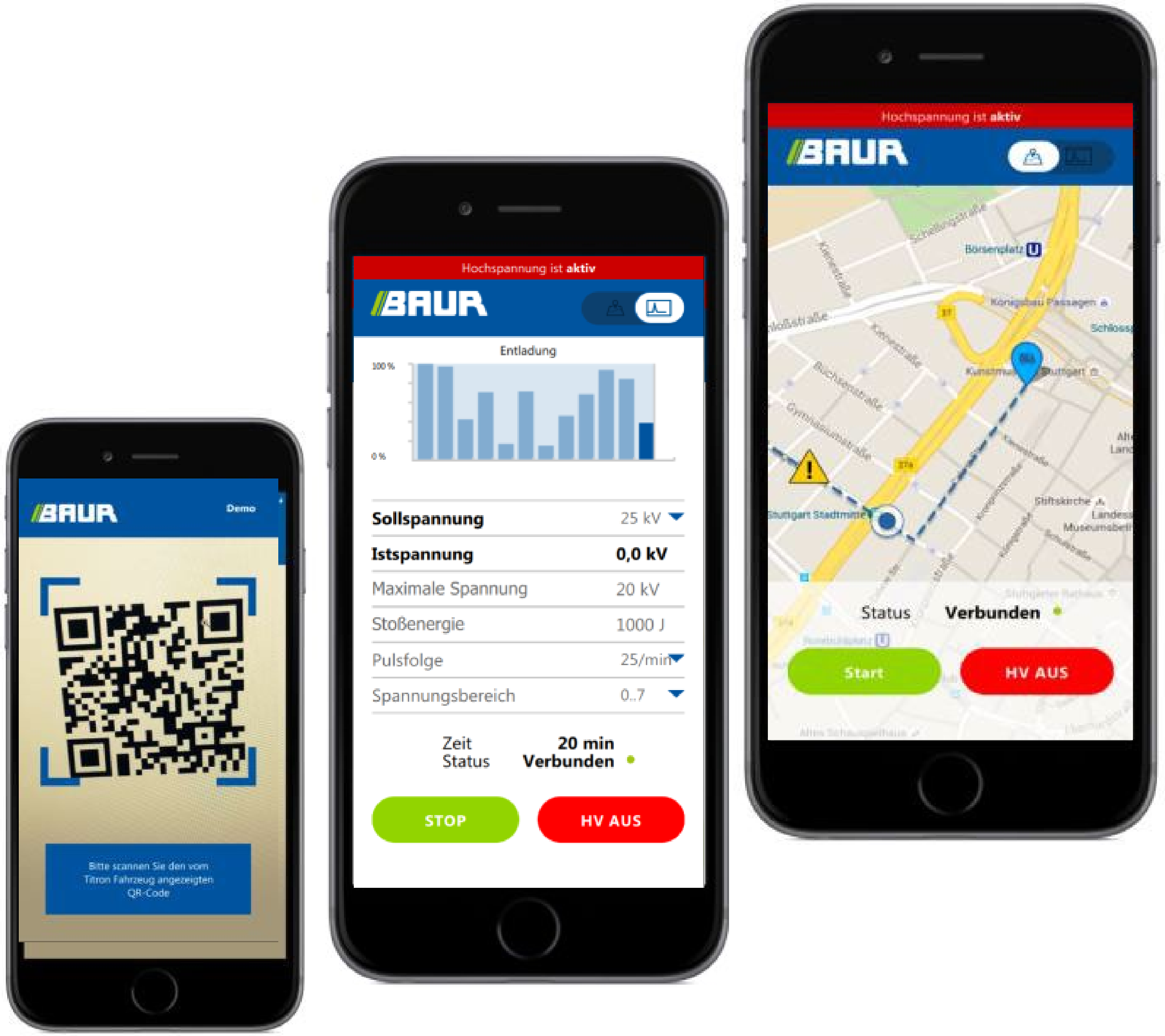
Cable fault location app

Map or fault location mode

- Leads the operator to the fault location
- Control of the titron® test van



ensuring the flow

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BAUR solution – XL cable fault location

Cable fault location expertise for land and submarine cables
Reliable fault location for maximum cost effectiveness

XL fault location system integrated in a container

- System mounted in a container
- High-performance DC voltage source, **110 KV** test voltage, **300 - 500 km discharge capacitance**
- Surge current generator 3000 J, burn down transformer 5.7 kVA, max. 90 A
- High-performance TDR, multi-method approach, differential decay method
- Extra-long connection cable for HV DC link

Cable fault pre-location methods

Method	Fault characteristics
Time Domain Reflectometry (**TDR**)	Low-resistive faults, breaks
Secondary/multiple impulse method (**SIM/MIM**)	High-resistive faults, breakdown faults
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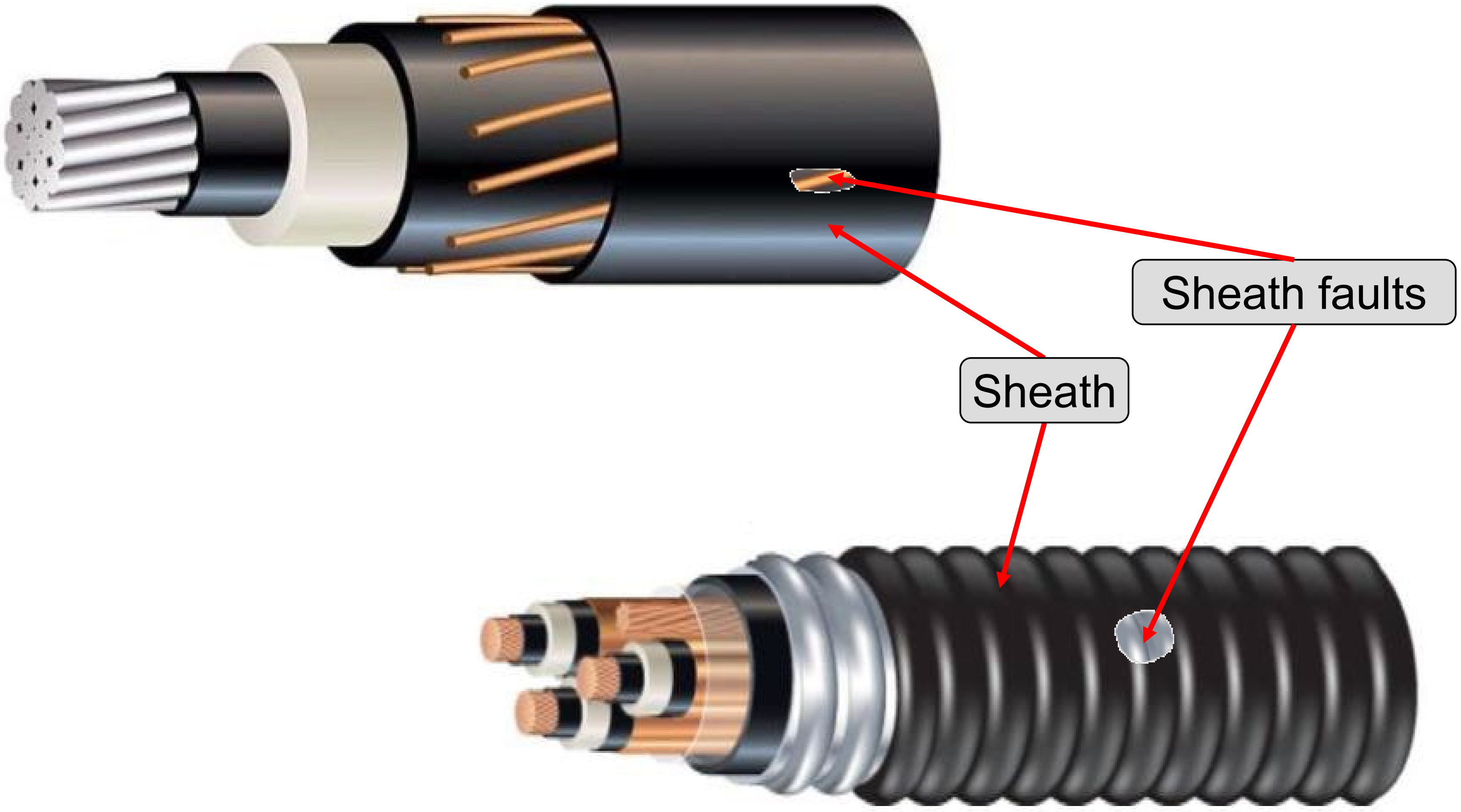
Travelling wave method/**decay** method	Voltage-ignited faults – if high voltage is required
3-phase current coupling	For branched cable systems
Bridge measurement	Low- and high-resistive faults, cable sheath faults

Bridge measurement – application

Fault location of:

- Sheath faults in MV and HV cables, cause of water trees
- All types of resistance faults in MV cables, backup for TDR measurement
- Fault location in LV and control cables

Sheath and cable fault location by means of bridge measurement



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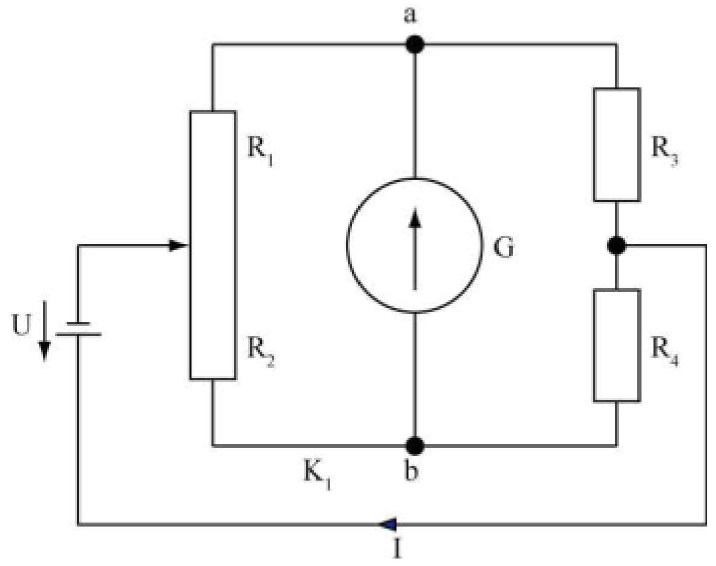
Bridge measurement – older forms of representation

Wheatstone circuit
(basic principle)

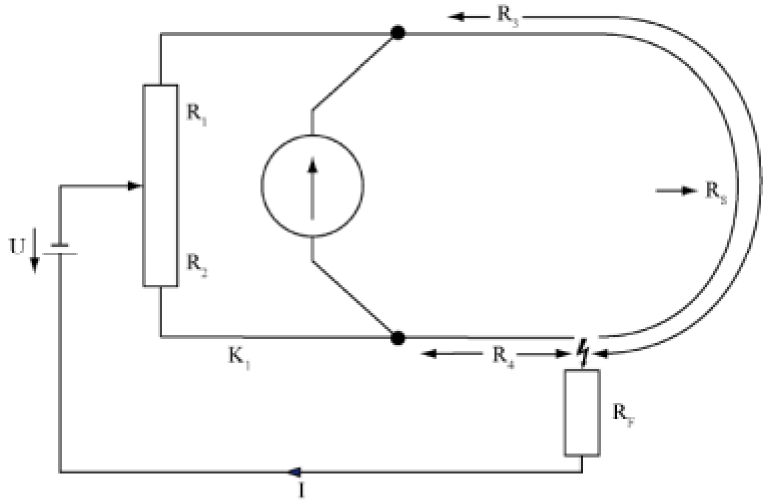


$$\frac{R_1}{R_3} = \frac{R_2}{R_4} \qquad R_4 = \frac{R_2}{R_1} \cdot R_3$$

Example

115 kV, cable characteristics

Plate, 175 mm² ~ 0.1 ohm/km series resistance



Residual current defines accuracy!

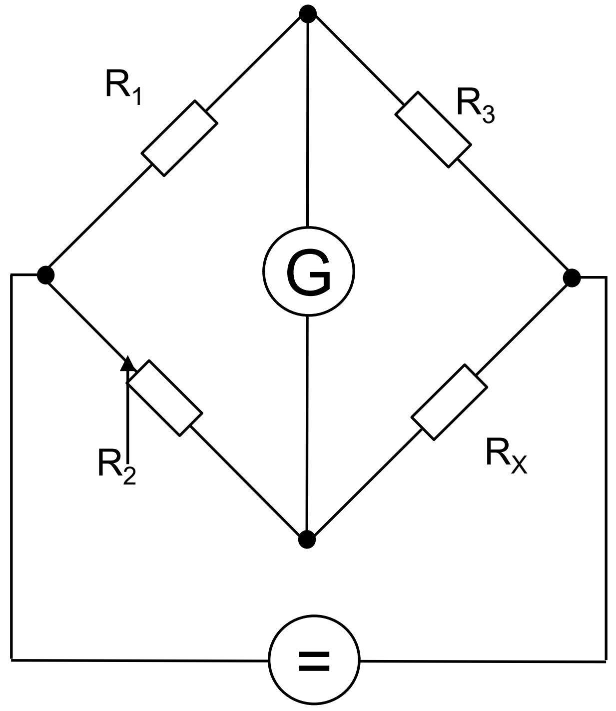
→ 2 - 3 mA required

→ at 10 kV = ~ 5 MOhm RF

Measuring bridge principle

The measuring bridges used in shirla are based on the basic principle of the Wheatstone bridge.

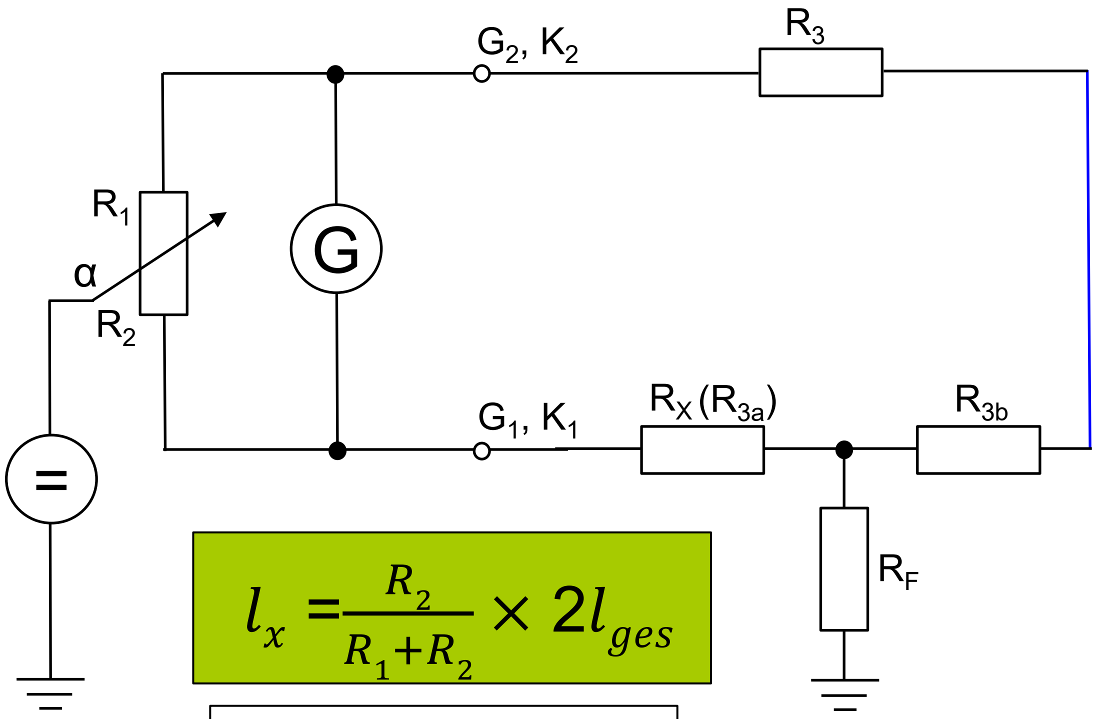
The bridge consists of two voltage dividers whose ratio in the balanced state corresponds to $\frac{R1}{R2} = \frac{R3}{Rx}$.



To achieve the balanced state, R2 is adjusted until measuring device G displays zero.
When R1 - R3 are known,
the value of
RX is determined by the resistance ratios $RX = \frac{R2}{R1} * R3$

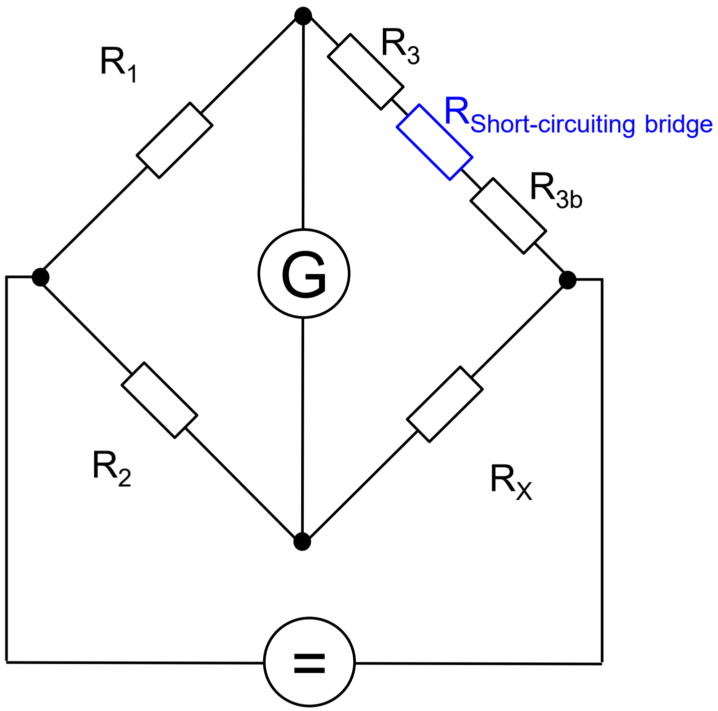
For the measuring bridges described below, RX represents the faulty cable and R3 represents another "auxiliary" cable.

Murray measuring bridge



$$l_x = \frac{R_2}{R_1+R_2} \times 2l_{ges}$$

$$l_x = \frac{2R_2}{R_1+R_2} \times l_{ges}$$



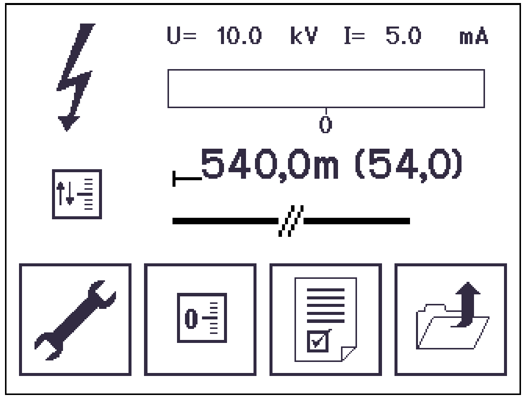
Murray

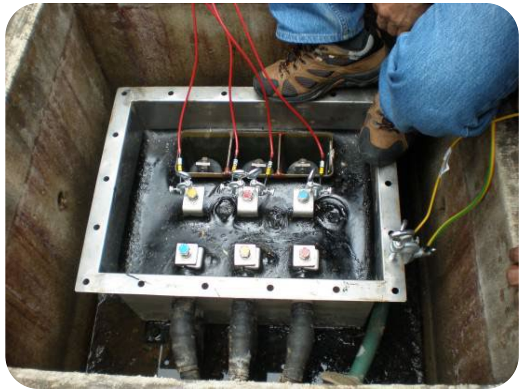
Bridge measurement

Sheath fault pre-location, earth faults

Features

- Automated balancing of the measuring bridge
- Option of entering various cable sectors
- Fault distance result in [m] and [%] for the total cable length
- Automatic adjustment of measurement voltage and current





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Sheath test and fault location system

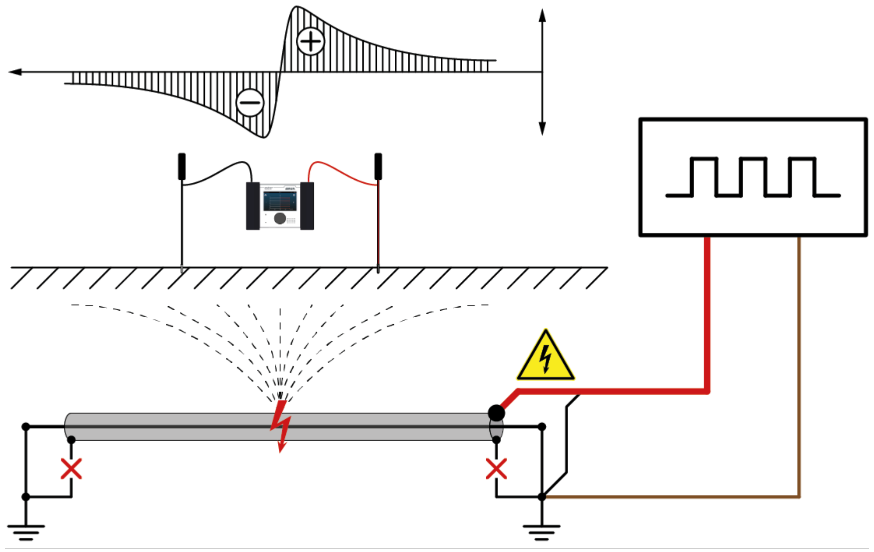
shirla

1. Cable sheath testing up to 10 kV
2. Cable fault and sheath fault location up to 10 kV
3. Cable sheath fault pin-pointing up to 10 kV

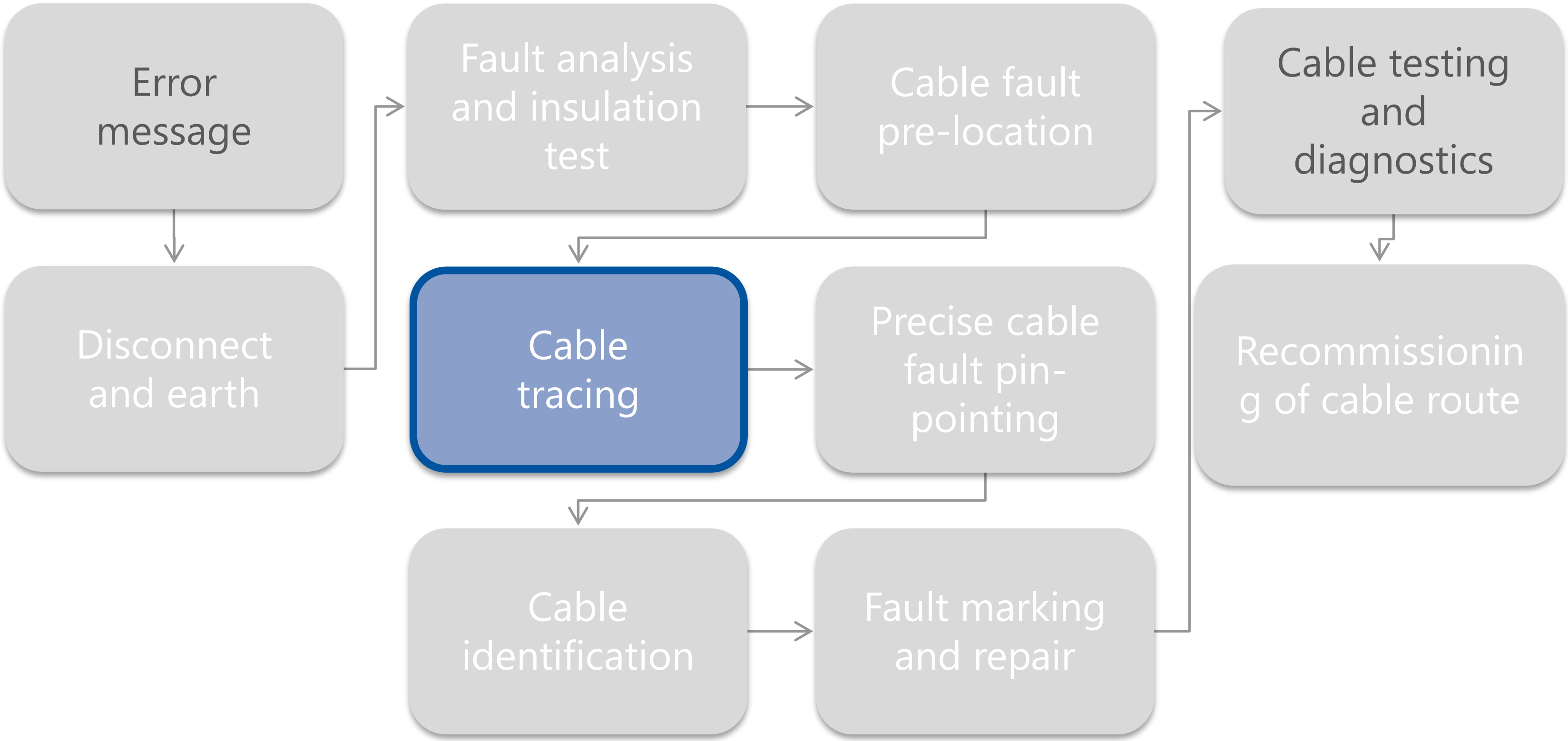
Application

Location of…

- **Sheath faults** in medium- and high-voltage cables
- **All resistive faults** in medium- and high-voltage cables → Backup instrument
- **Fault location in low-voltage** and control cables



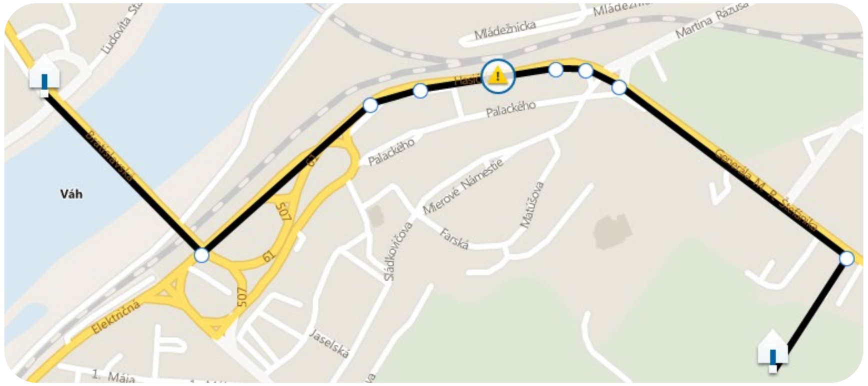
Cable tracing

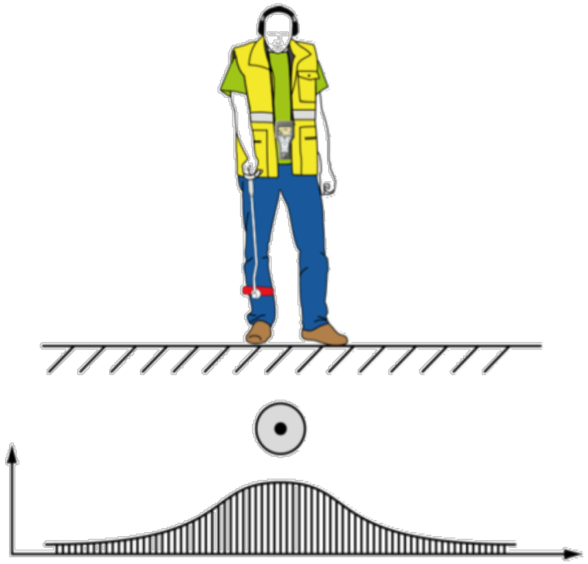


Cable tracing

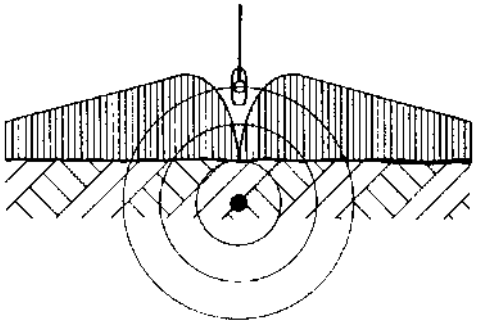
Determination of the cable route

Signal source:
Audio frequency transmitter

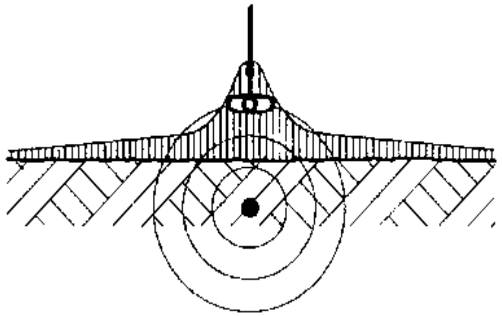




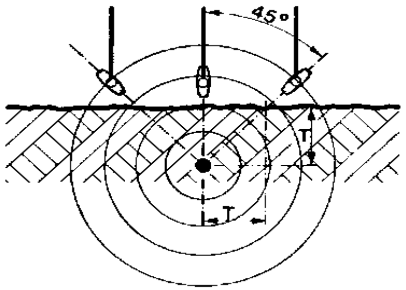
1. Minimum method



2. Maximum method



3. Depth measurement

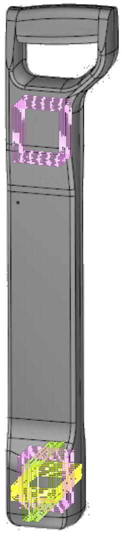


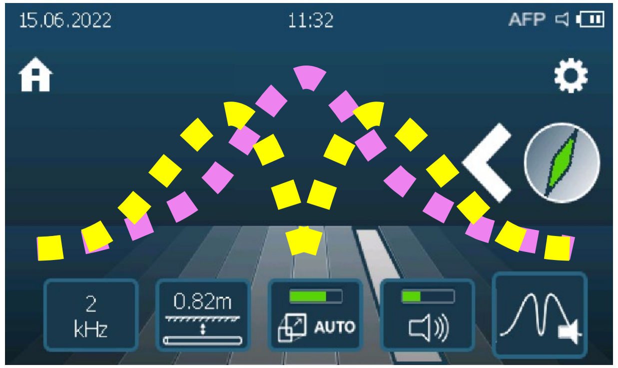
Cable tracing

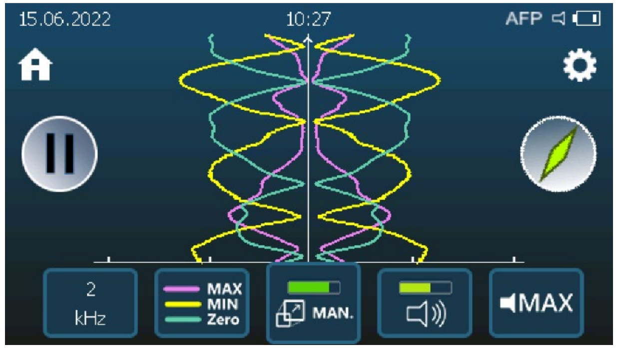
Protrac tracing set - AFP

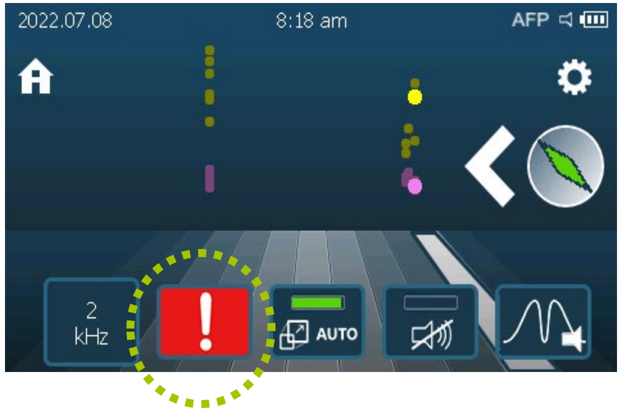
1. Reduced downtime
2. Reduced risk of unnecessary excavations
3. Very simple and convenient operation
4. Precise depth measurement

“Tracing” set









Benefits…

- **No need** of manual alignment
- **Deviation Alert** eliminates misdirection
- **3D History track** for more accurate measurement seq.
- **Tracing Compass** keeps the user on track

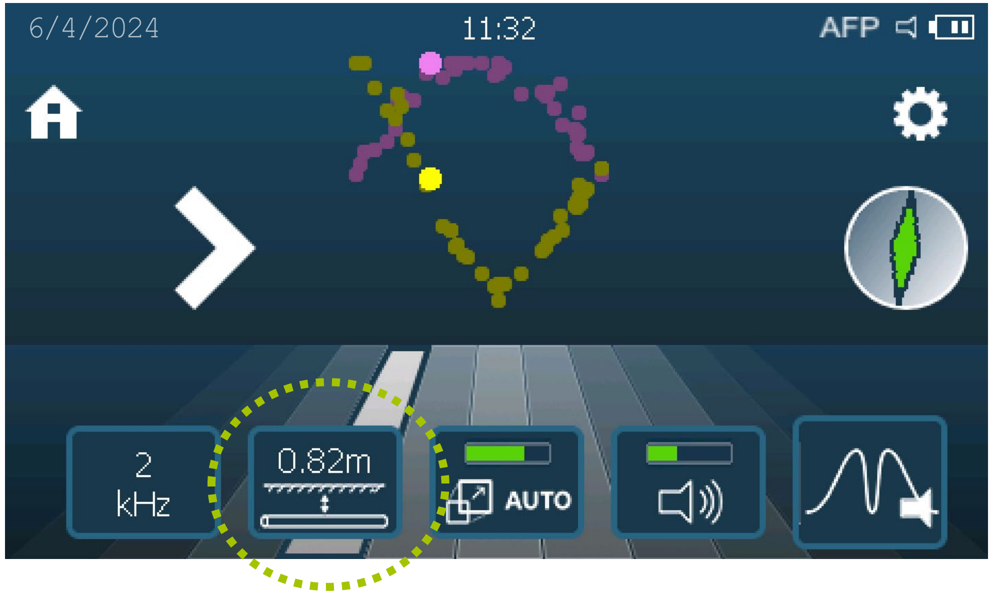
Measure the depth reliably

Depth at the touch of a button

Direct display of the depth

Depth at the touch of a button

Easy depth measurement



Tracing data supplemented with depth information

Recognition of installation faults

45° depth measurement

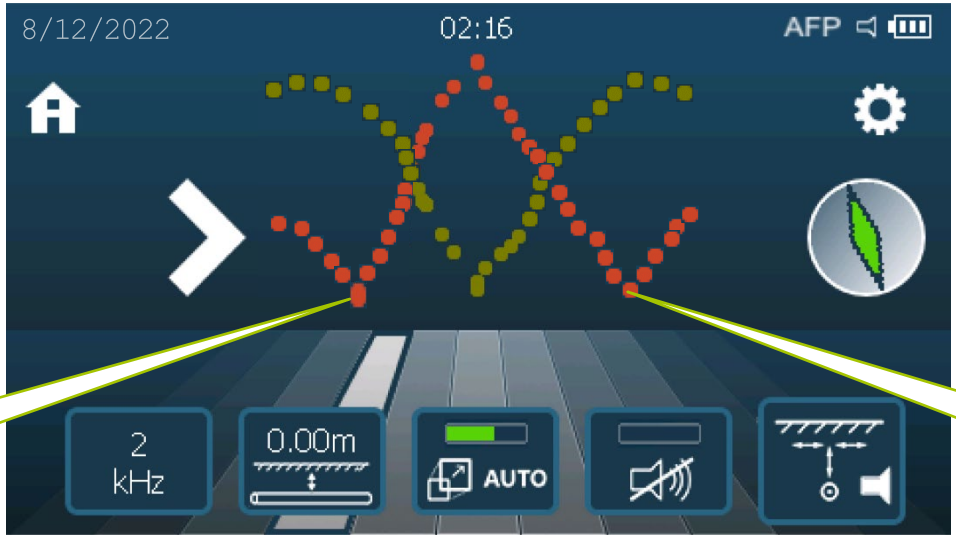
Identify field distortions

Determine the depth easily via 45° measurement

Depth measurement without adjusting coils

Easy detection of asymmetrical fields

Left 45° minimum

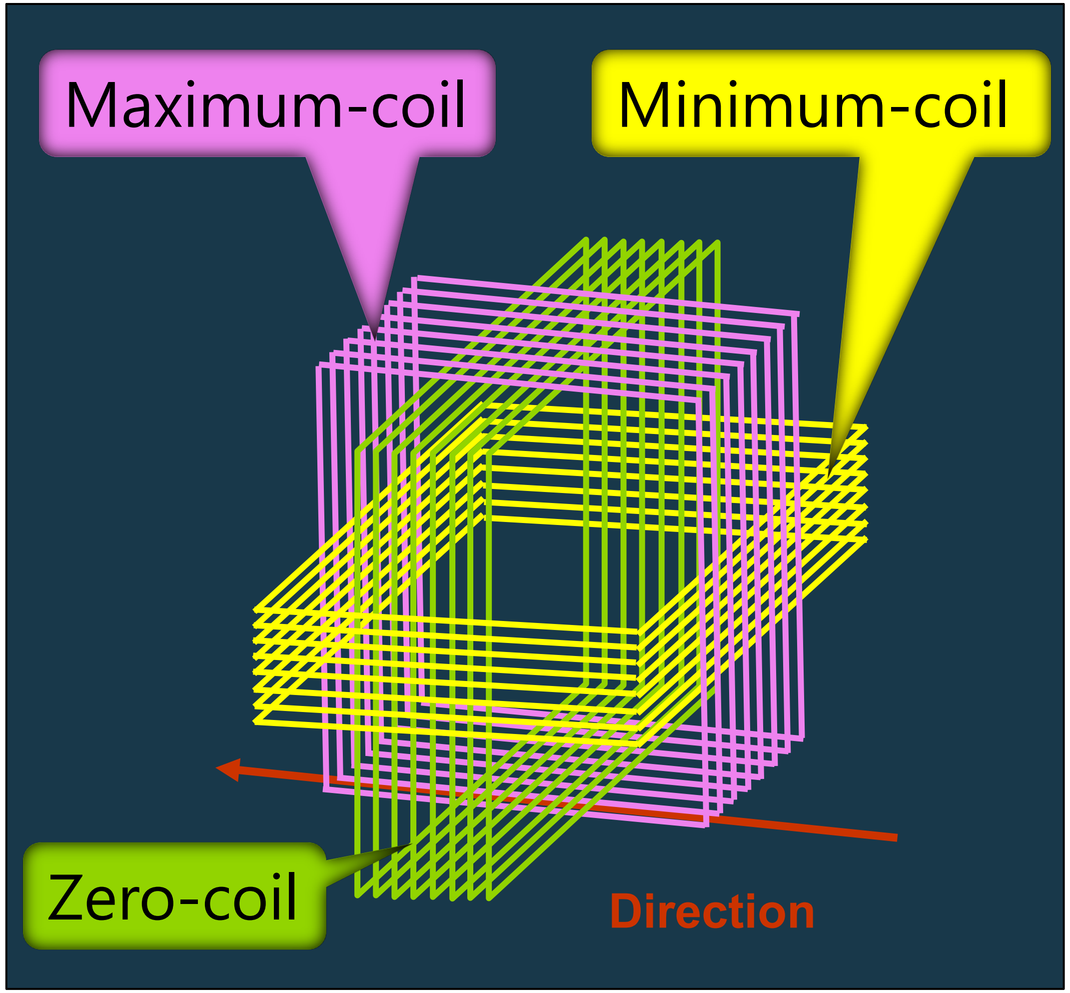


Prevention of excavation-related cable damage

Warning about unclear position conditions

Right 45° minimum

The 3D space coil



- The 3D coil arrangement allows a immediate evaluation and comparison of all the coil data.

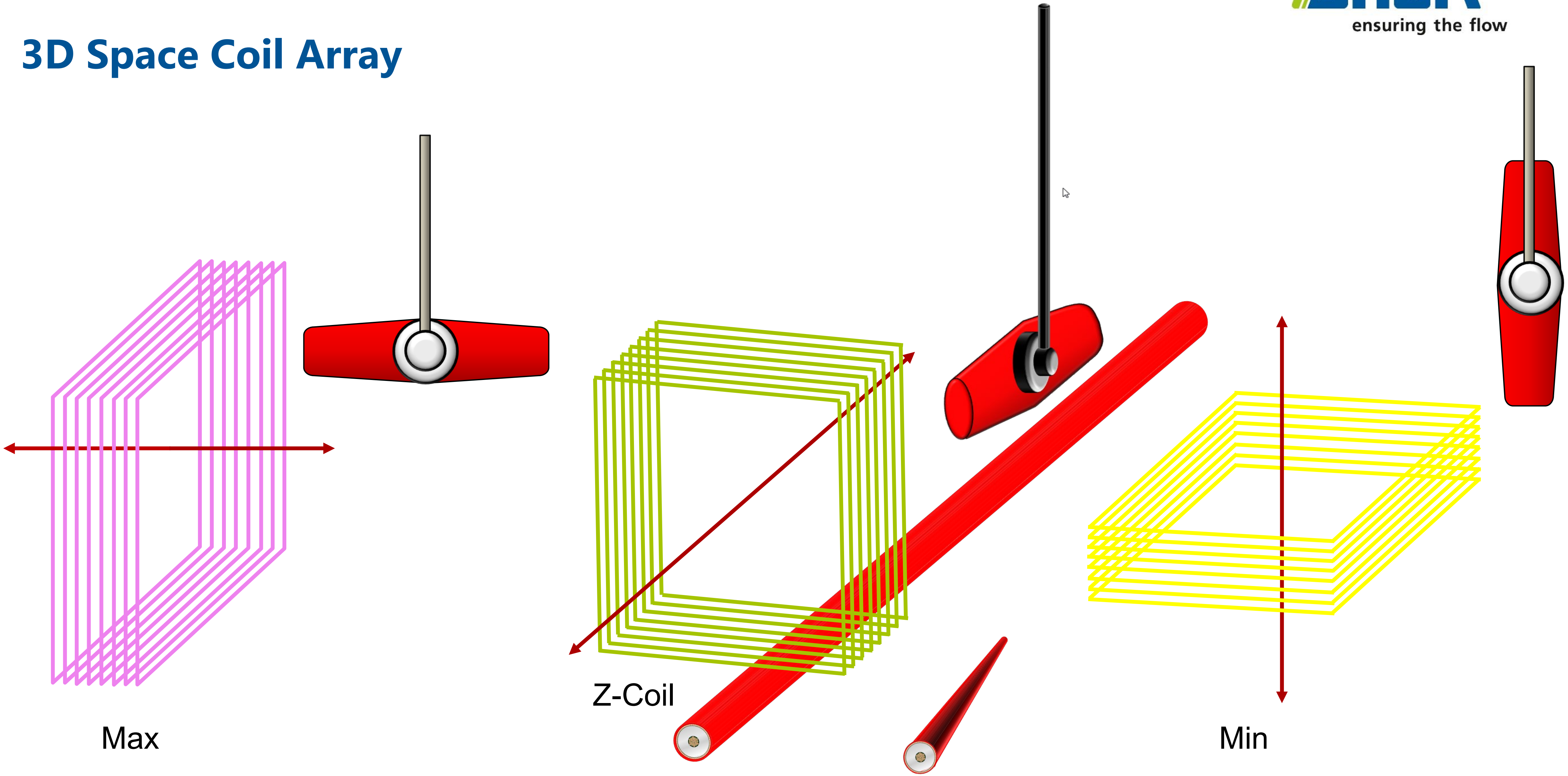
- Angular deviations can be used to determine the direction of the cable and thus to provide the Compass Tracing Guidance function

X = Maximum coil (2x for direct depth measurement)

Y = Minimum coil

Z = Parallel coil (parallel to the cable path)

3D Space Coil Array



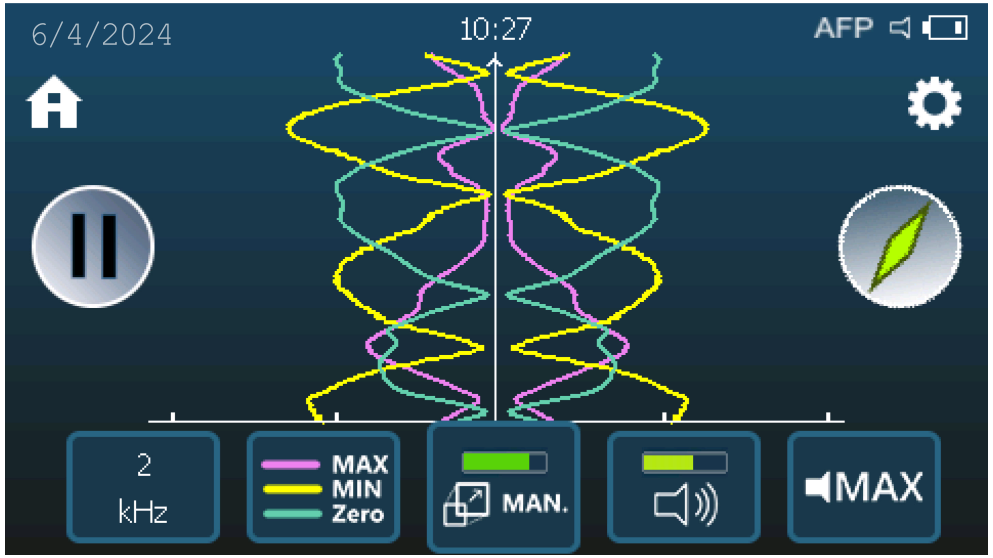
Detect changes quickly and easily

3D History Track provides simple visualisation

Selectable display of the historical data of 3D Space coils over a defined period of time or distance

Important data are visible for longer for comparison purposes

Simplified operation, especially for the complex short-circuit fault location



Differences and changes are more evident

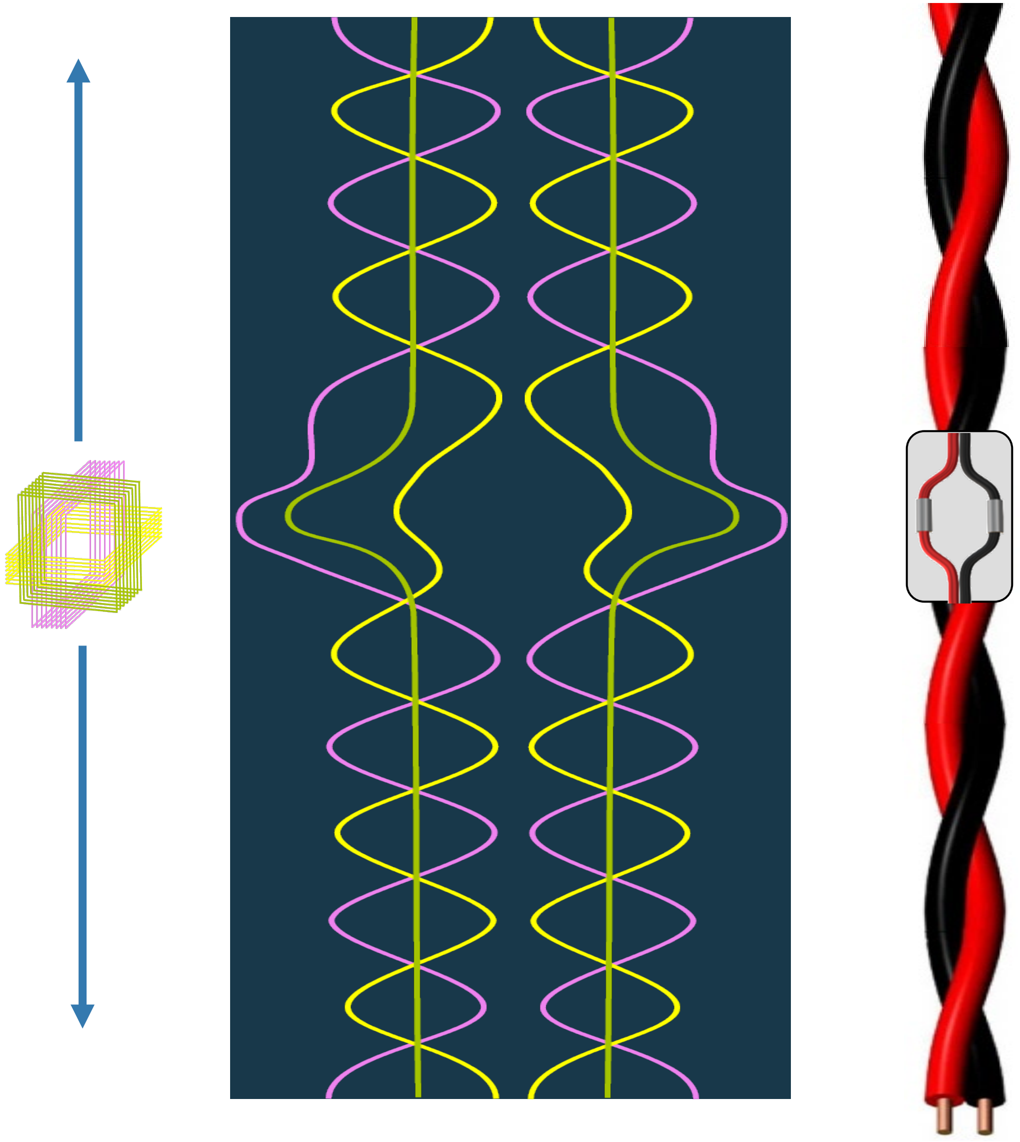
Adjustable duration of display time, and storable by the Hold key

Each coil can be selected separately

3D History Track

3D Magnetic field response during Audio Frequency twist method on twisted cables.

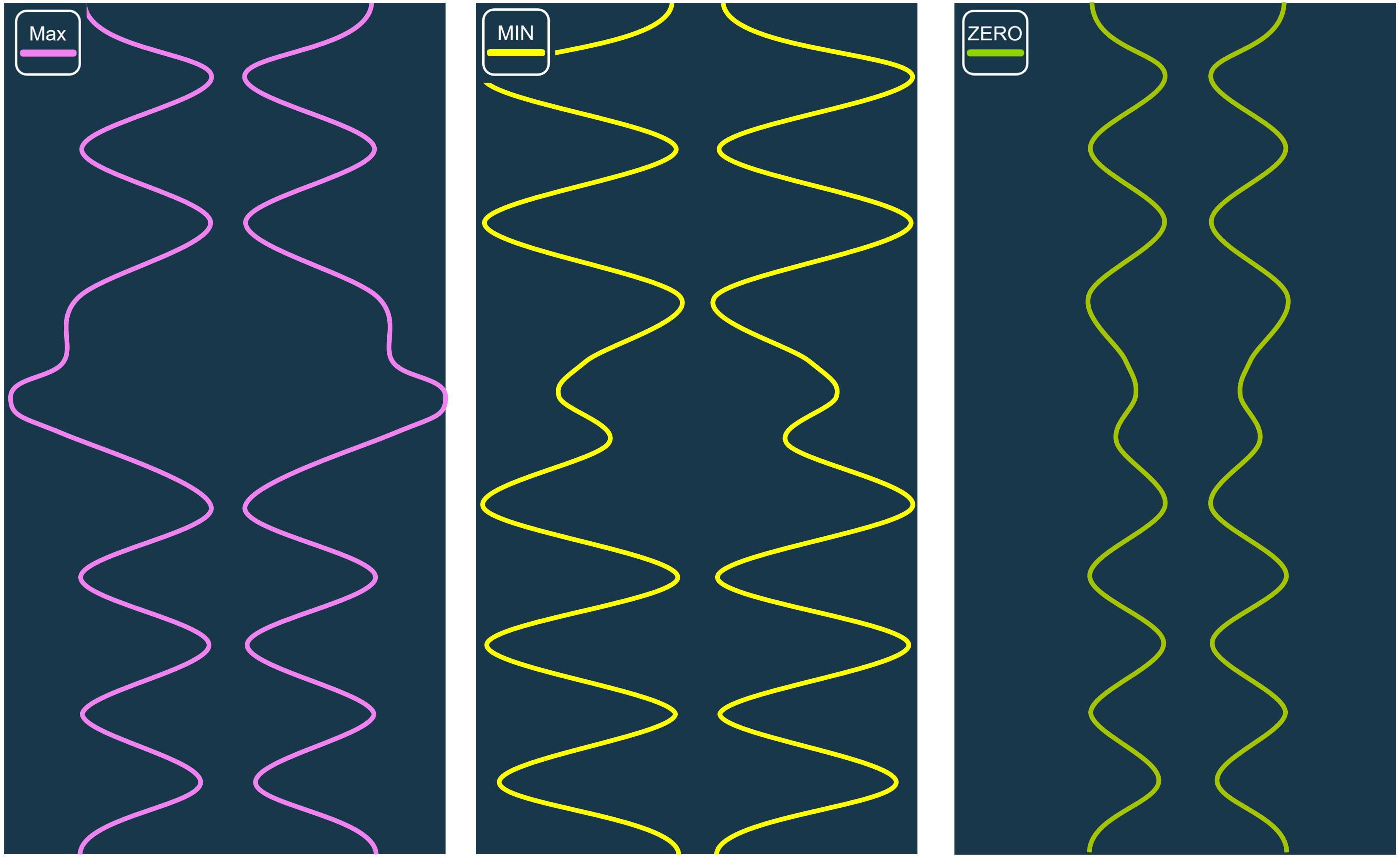
In the twist mode, the 3D History Track shows the lay lengths and the deviation or interrupt of the regular 3 coil lay length based regular oscillation in the case of a joint or fault.



3D History Track

Samples of single coils.

Depending on the situation, the view of one single coil may be easier to evaluate As too many lines in one display can be confusing.

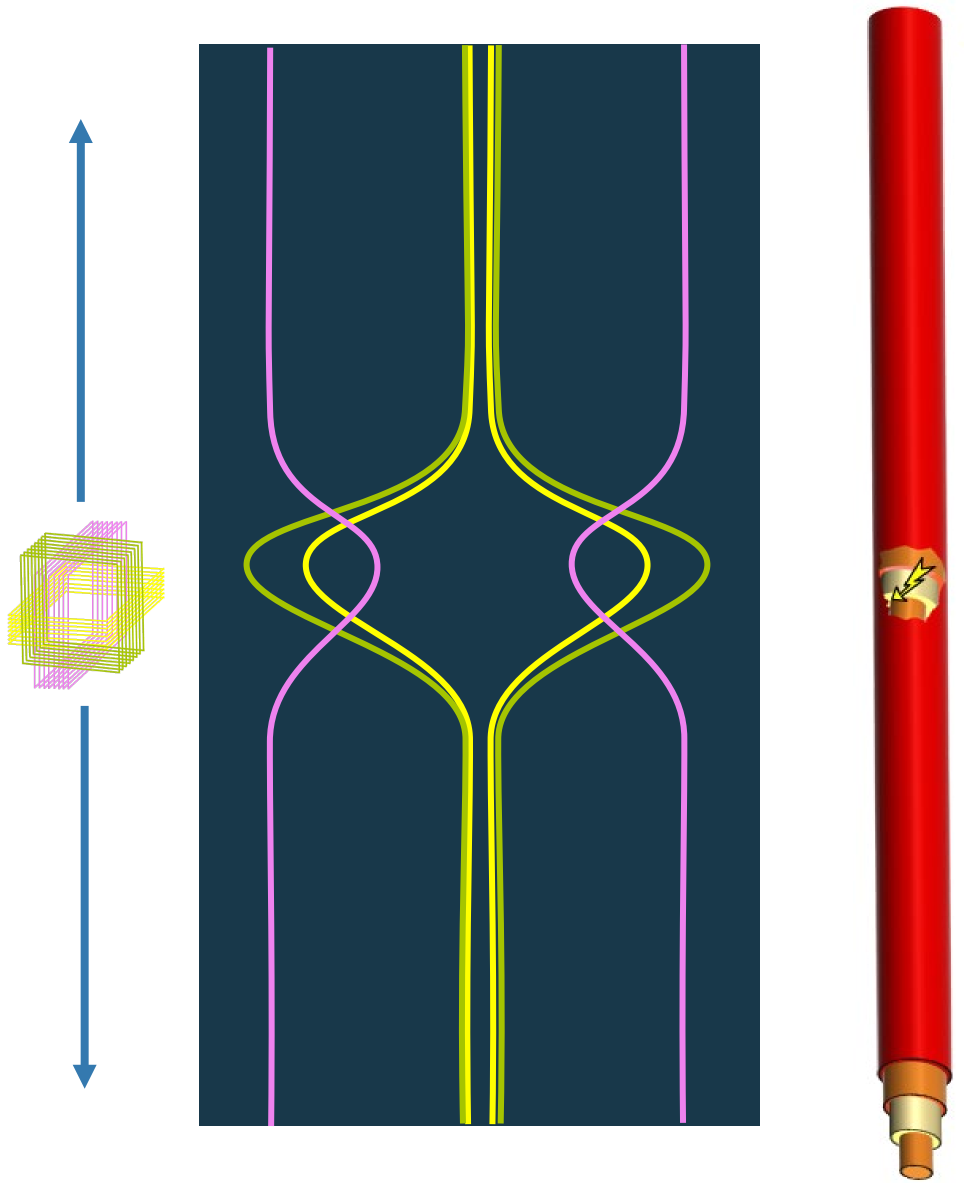


3D History Track

3D Magnetic field response during minimum distortion method for MV coaxial Cables.

During the tracing procedure the yellow (Minimum) and green (zero) lines must be a narrow as possible, thus guiding the user exactly on top of the cable. In opposition the magenta lines (Maximum) which will be spread wide apart.

Approaching a joint or the fault, the response of the lines will reverse their appearance simultaneously, thus indicating a disturbance in the electromagnetic field.



3D History Track

video

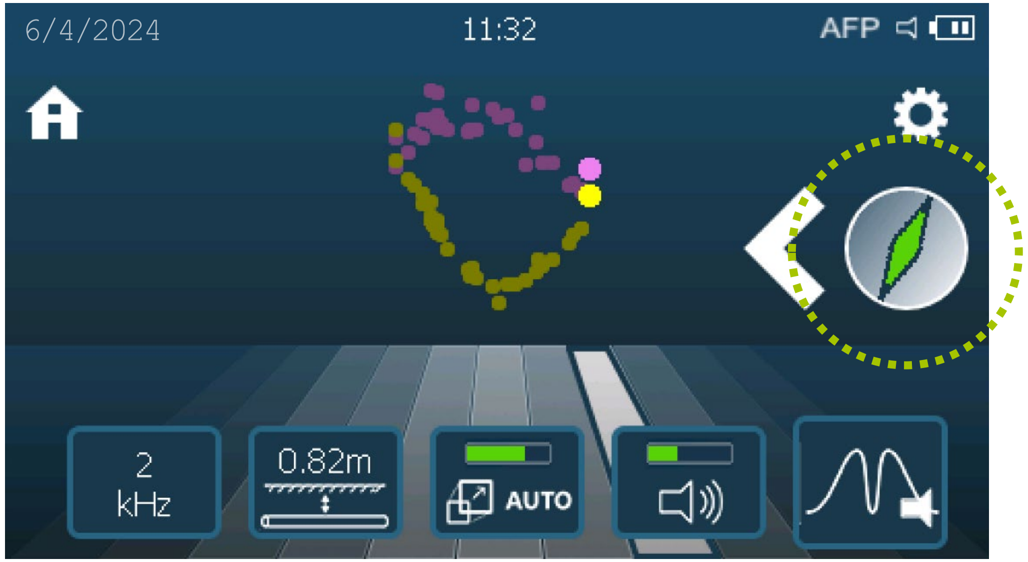
Identify changes in direction immediately

Tracing Compass

Displays changes in the direction of the cable

Immediate correction if direction changes

No unintended leaving the cable route



Less time lost

More precise tracing

Simplified workflow

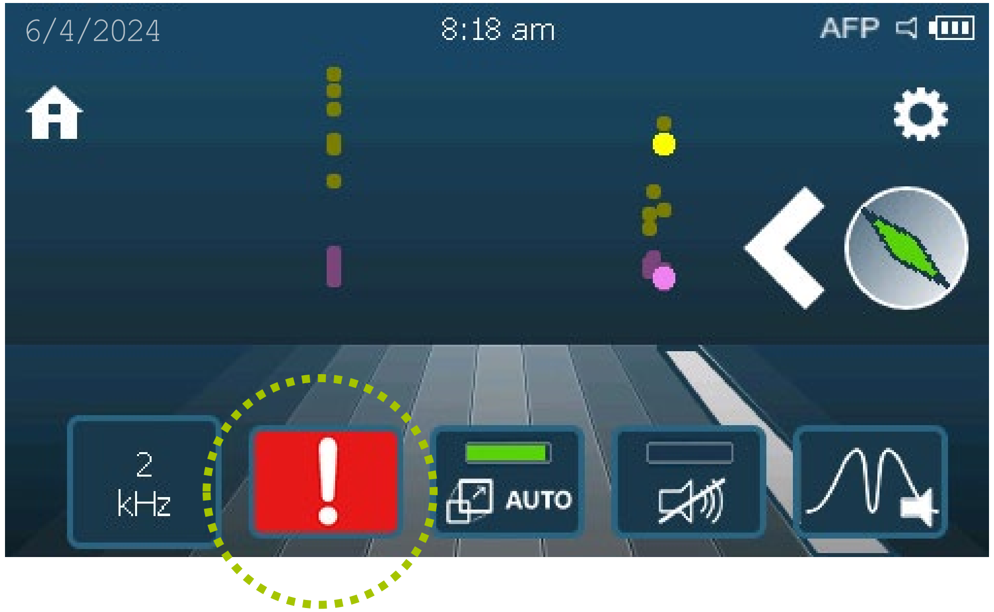
Eliminates misdirection

Deviation Alert

Issues an alarm when the relationship between the upper or lower magnetic field lines changes

Avoids incorrect tracing

Immediate Alarm when interference occurs e.g. overhead lines



Less time lost

Assures the user he is "doing the right thing"

Simplified work flow

Assessment of the signal quality

Current indicator

The current indicator displays the quality of the signal in the cable

Detection of branches by distributing the current

Comparison with the output current of the TG

Statement on quality of signal and current flow

Information on the quality of the connection

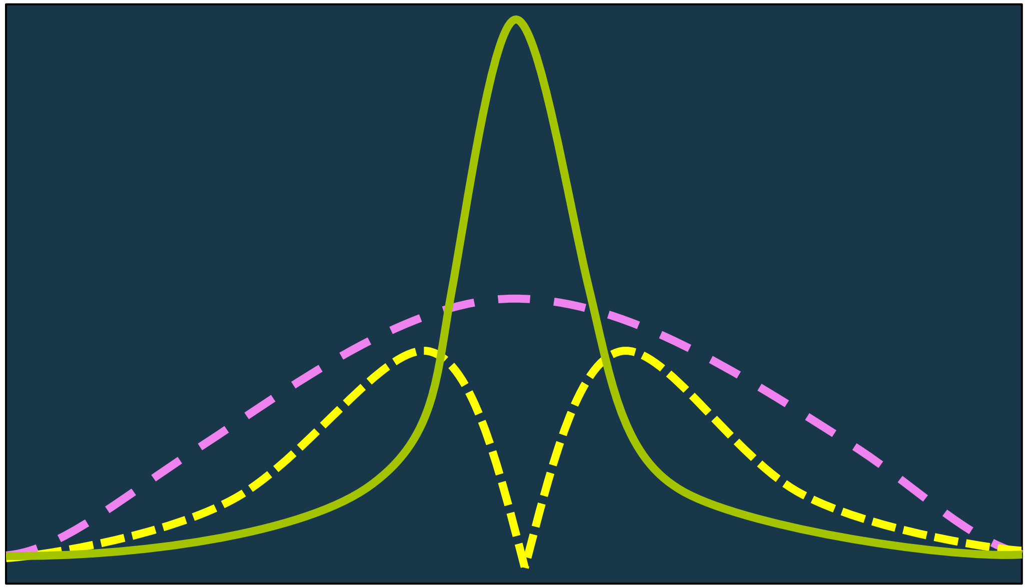
All advantages combined

C-Max

A combination of the maximum and inverted minimum signal provides a much clearer result.

Clearer peak signal

Combines the advantages of minimum and maximum methods



Faster, more precise operation

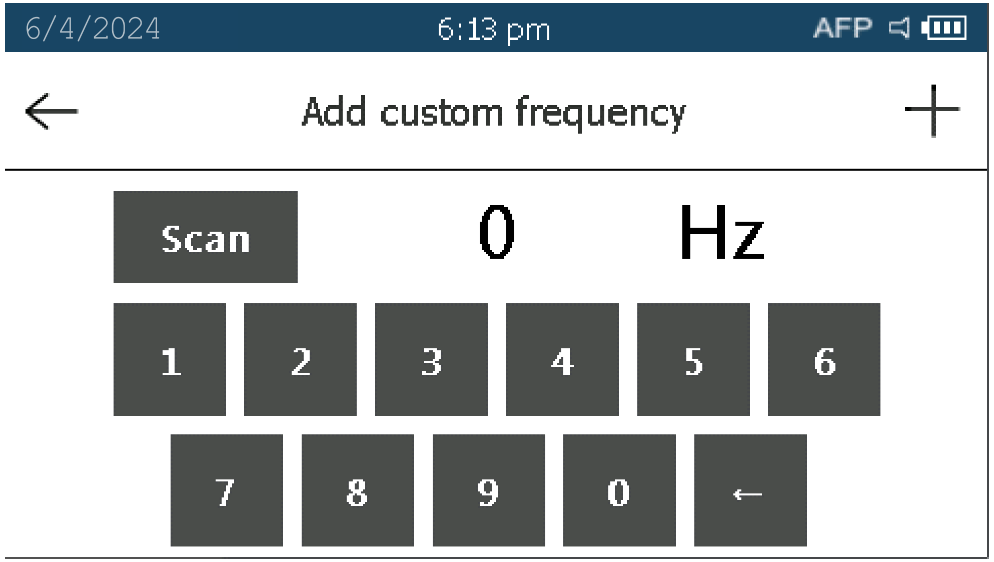
Tracing made easier

Manual or automatic frequency setting

Adjustable in 1 Hz steps

Scan mode for automatic frequency detection

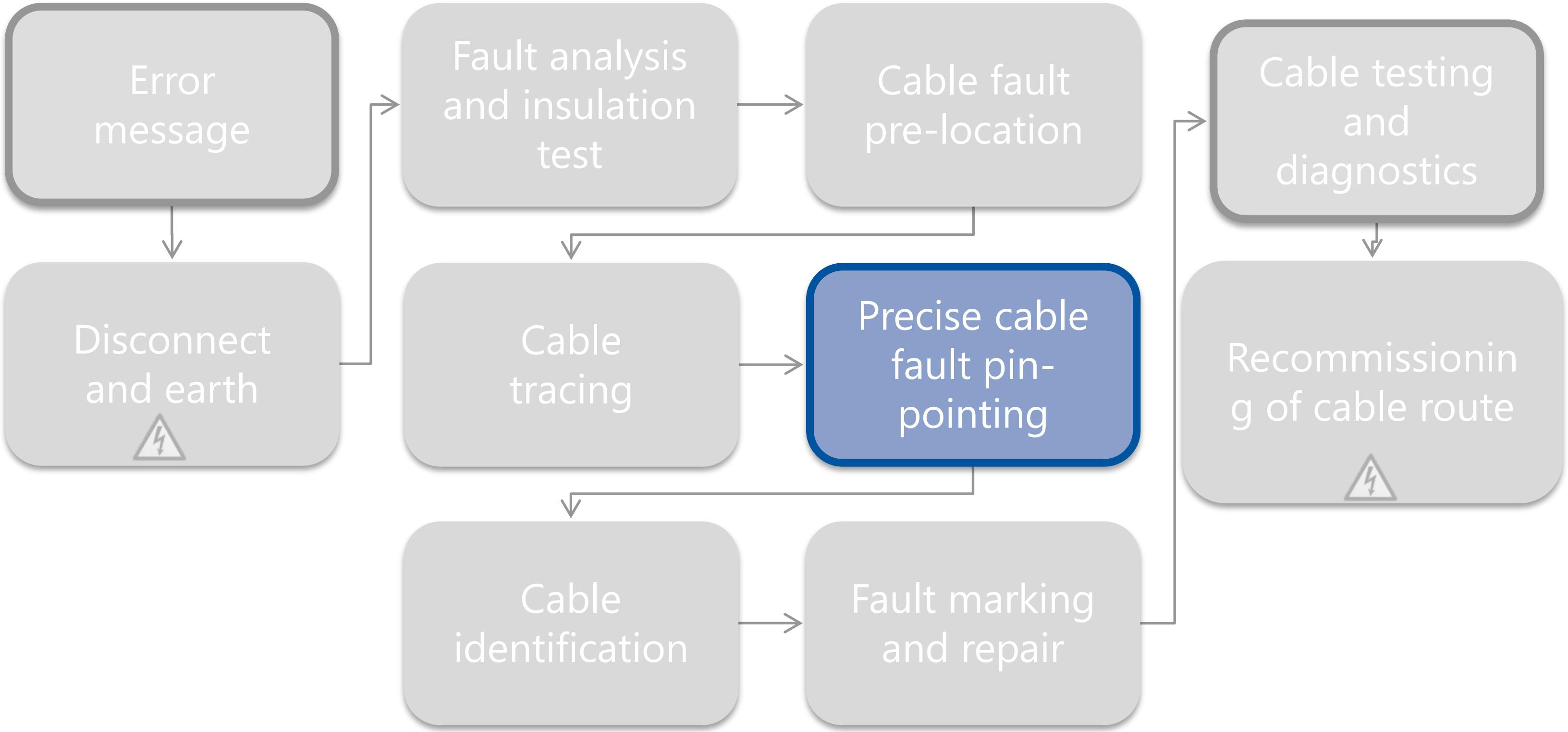
Frequencies can be saved without limit



Frequencies adjustable from 16 Hz to 15 kHz

Pre-installed frequencies: 491, 982, 2000, 8440, 10000 Hz and *All* for AGP and AFP. The AGP does not have free frequency selection.

Precise cable fault pin-pointing



Cable fault pin-pointing

Precise location

Acoustic fault pin-pointing

Determination of the exact fault position

Signal source: Surge generator

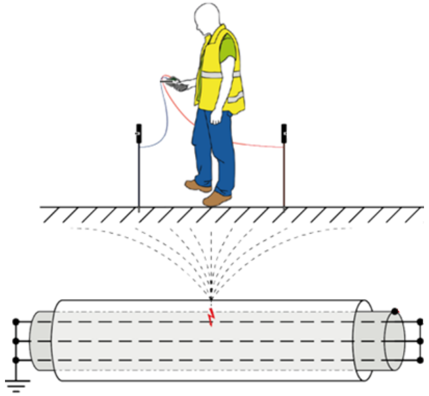
- For phase/sheath faults, phase/phase faults

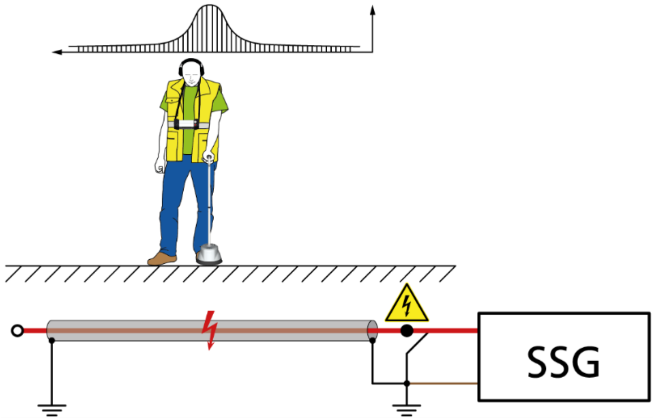
Step voltage method

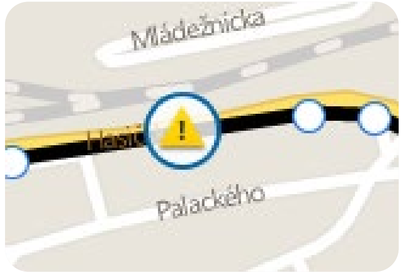
Determination of the exact fault position

Signal source: High-voltage pulse pattern

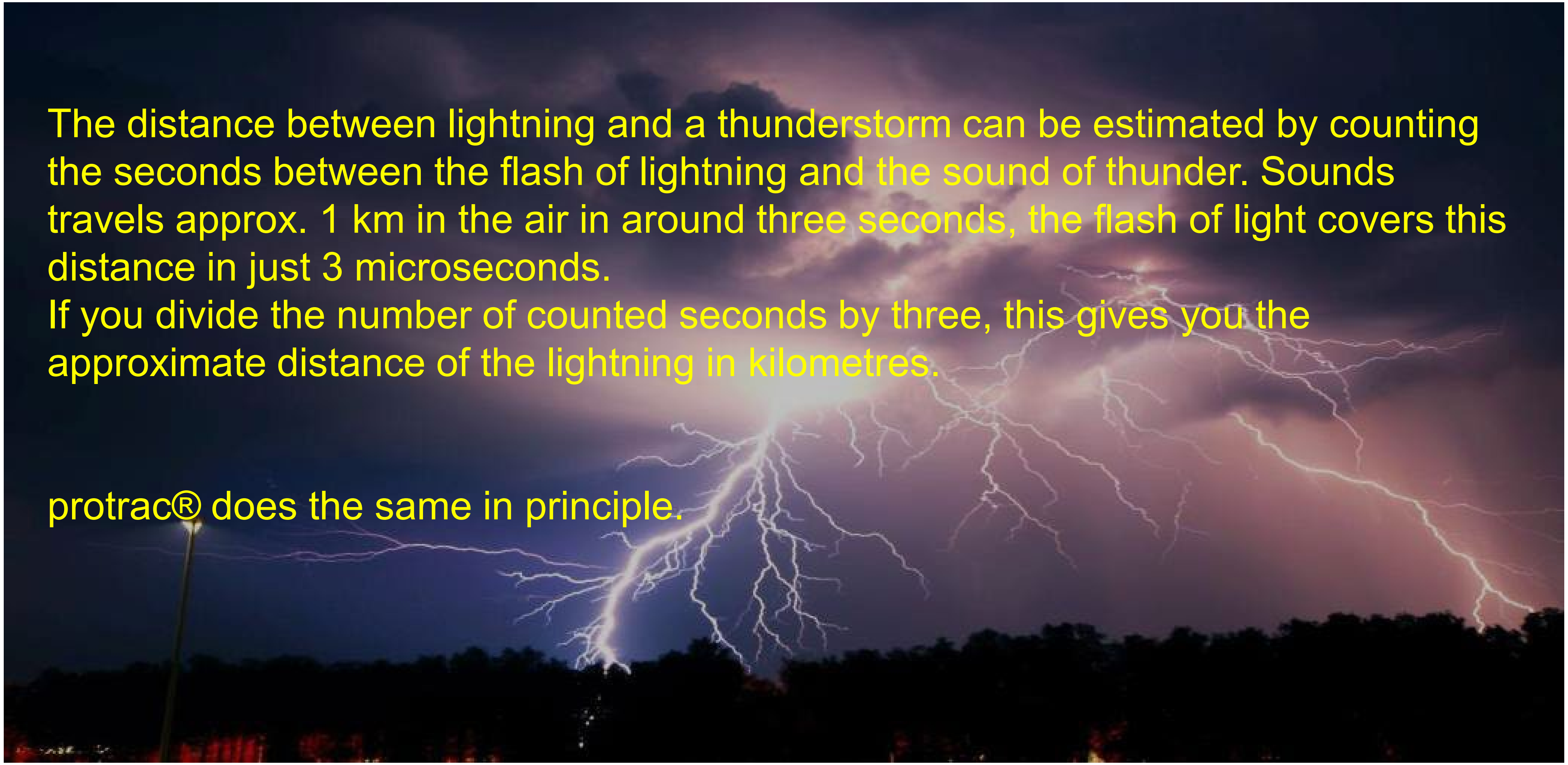
- For sheath faults, earth faults





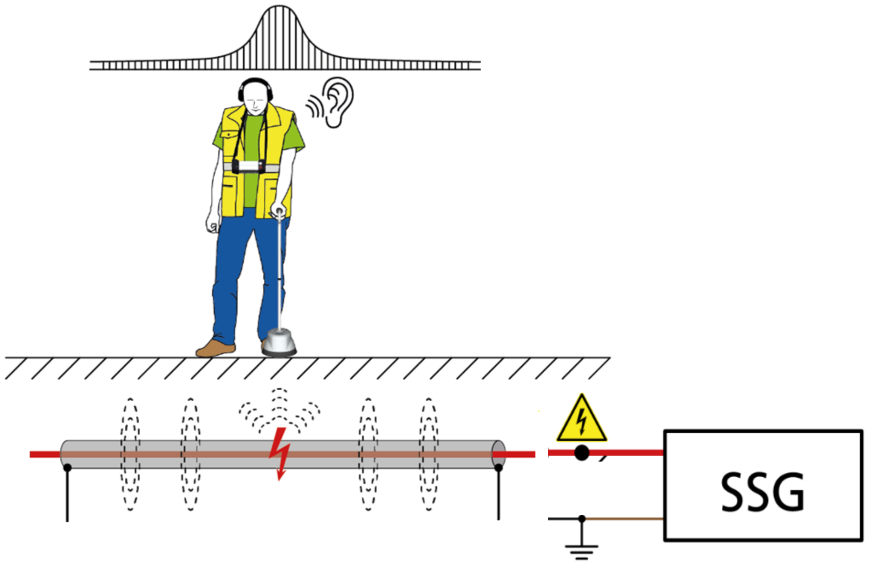


The thunder and lightning principle (coincidence method)



Coincidence method

The shortest time defines the correct position –
not the volume!



Magnetic pick-up
+ acoustic signal
➔ Duration measurement
➔ Meter display

Protrac®

BAUR system for fast and precise cable fault pin-pointing

Protrac®

Connections via Bluetooth

1. SVP step voltage probes
2. CU control unit
3. Bluetooth headphones
4. AFP audio frequency probe
5. AGP acoustic ground probe


Fault pin-pointing with AGP
6/4/2024
7:28 am
AGP
3,4 m
3,0 m
2,8 m
45
25
76
0
85
dB(A)
ANS
Sheath fault location with SVP
6/4/2024
9:04 am
SVP
mV
-1
1
MAN.
rotrac
ntrol Unit
BAUR
.2021
11:51 am
AFP
Acoustic pin-pointing
Sheath fault location
Settings
Tracing
History Track
Tracing with AFP or AGP
8/12/2022
11:32
AFP
2
kHz
0.82m
AUTO
3D history display with AFP
8/12/2022
10:27
AFP
2
kHz
MAX
MIN
Zero
MAN.
MAX

Protrac®

Evaluation of the acoustic and electromagnetic signals

You are directly above the cable route and the cable fault is located approx. 2.6 m in front of you.

You are to the left of the cable route and the cable fault is located approx. 2.6 m in front of you.

You are directly above the cable route and the cable fault is located approx. 1.3 m behind you.

You are to the right of the cable route and the cable fault is located approx. 1.3 m behind you.

You are directly above the cable route and approx. 2.6 m from the cable fault.

A second measurement must be performed to determine the direction in which the fault is located.

You are directly above the cable route, but no acoustic signal has been detected.

Due to the lack of an acoustic signal, it is not possible to determine the distance from the fault and this is shown as "...".

Cable pinpointing

Protrac control unit - CU

1. Simple navigation with 3D presentation
2. Convenient operation without cable
3. Operator safety by integrated loudspeaker
4. Intuitive operation with touch display or encoder

“Acoustics” set

Protrac acoustic ground probe - AGP

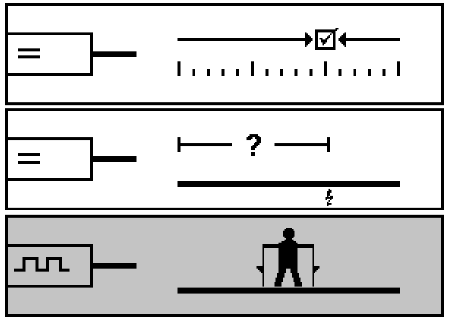
1. Long-lasting operation whatever the environment
2. Convenient operation and flexibility
3. Noise suppression and mute function

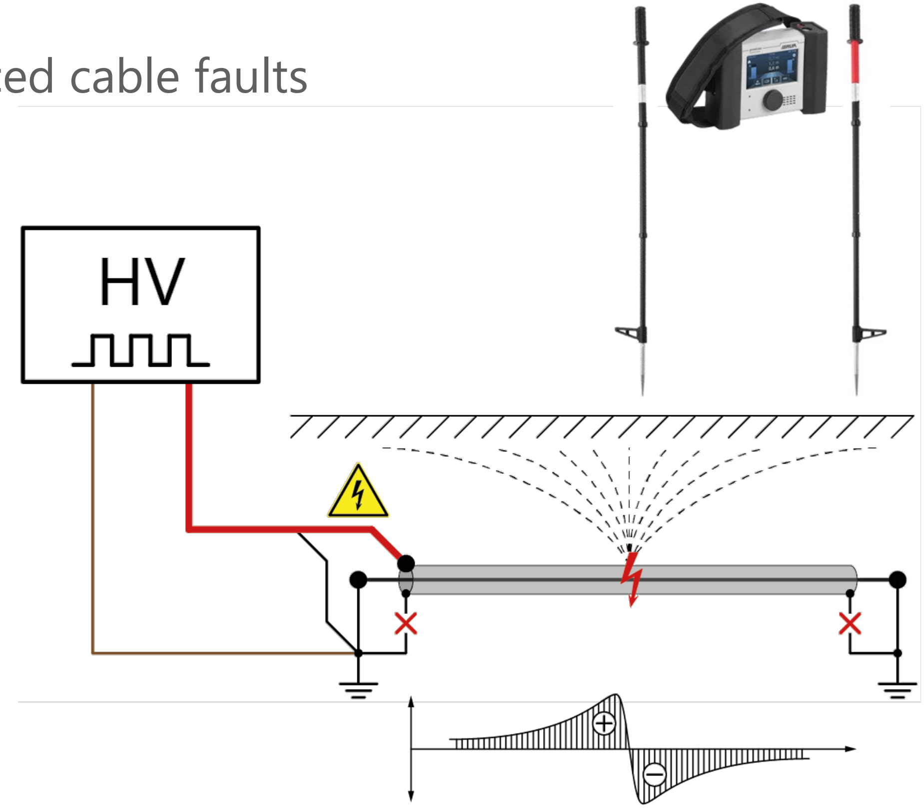
DC step voltage method

RCC ELECTRONICS LTD.
Licensed Canadian Distributors
Tel: 905-669-6644
Toll-free: 1-800-668-6053
Fax: 905-669-6645
E-mail: sales@rcce.com
Website: www.rcce.com

Detection of:

- Sheath faults
- All other earth-referenced cable faults



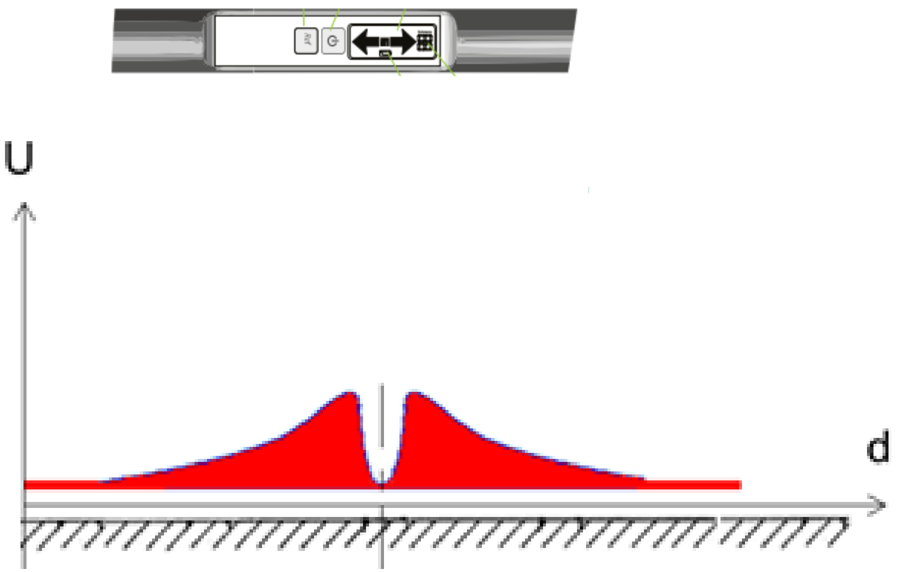


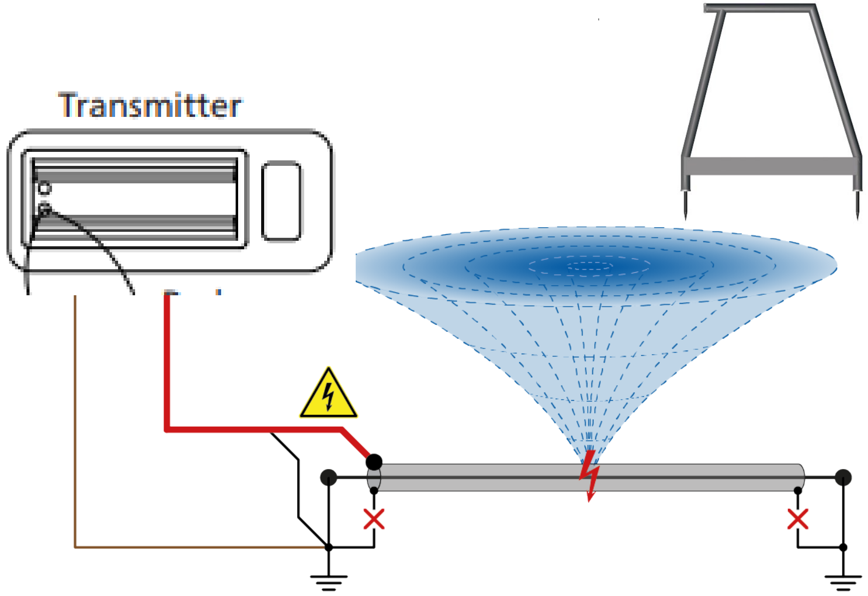
step voltage method with AC

Fault location with AC signal

No direction display unlike the DC method

- The receiver only indicates a minimum above the fault location
- CL 20 – staff A-frame



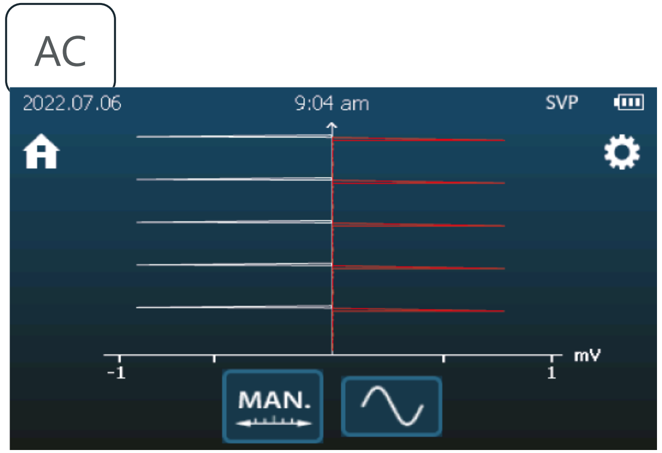


Cable pinpointing

Protrac step voltage probe - SVP

1. Automatic or manual adjustment to the step voltage
2. Wide measurement range from 1µV – 220V
3. AC or DC measurement
4. Automatic zero point adjustment of DC offset

"Step voltage" set

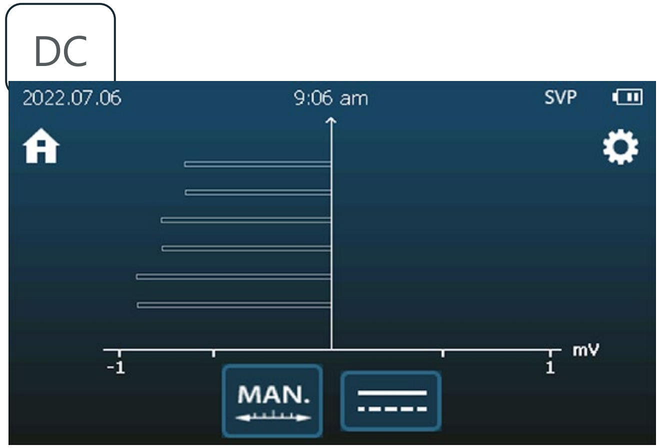


Location of sheath and earth faults…

- **History display of all changes** in the step voltage measurements in the last 12 seconds
- **Automatic offset compensation** in DC mode
- **Automatic filter**

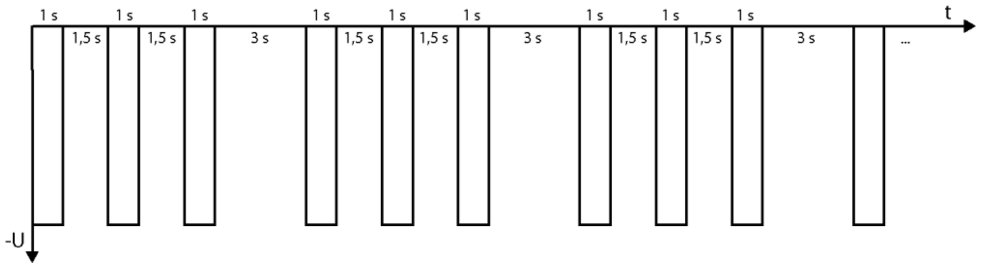
  DC – direct measurement

  AC – capacitive decoupling especially with distorted signals



Sheath fault location in DC mode

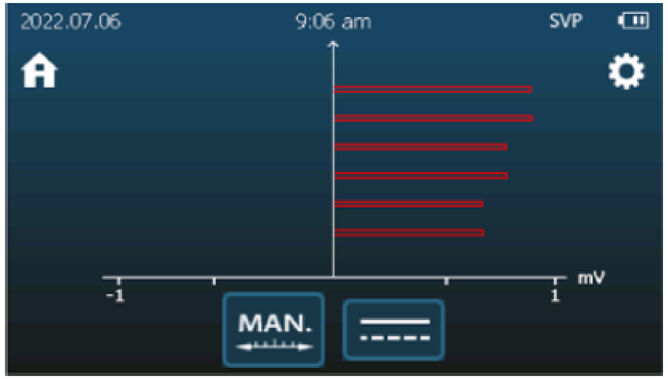
Protrac step voltage probe - SVP



Cable sheath fault to the left of the operator

Negative DC pulses (deflection to the left)

The increasing signal strength at the bottom of the touchscreen shows that you are moving closer to the cable sheath fault.



Cable sheath fault to the right of the operator

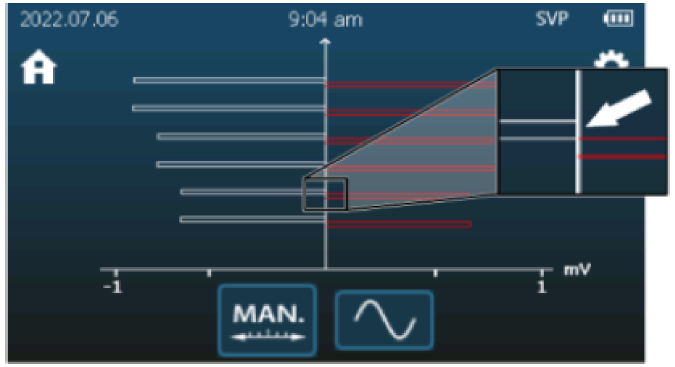
Positive DC pulses (deflection to the right)

The decreasing signal strength at the bottom of the touchscreen shows that you are moving away from the cable sheath fault.

“Step voltage” set

Sheath fault location in AC mode

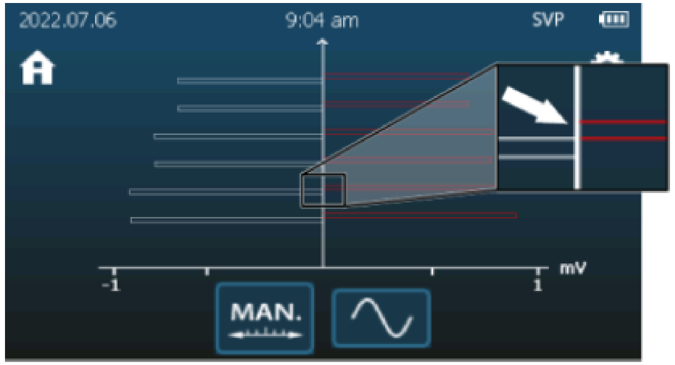
Protrac step voltage probe - SVP



Cable sheath fault to the left of the operator

The first half-wave of the signal has negative polarity.

The decreasing signal strength at the bottom of the touchscreen shows that you are moving away from the cable sheath fault.



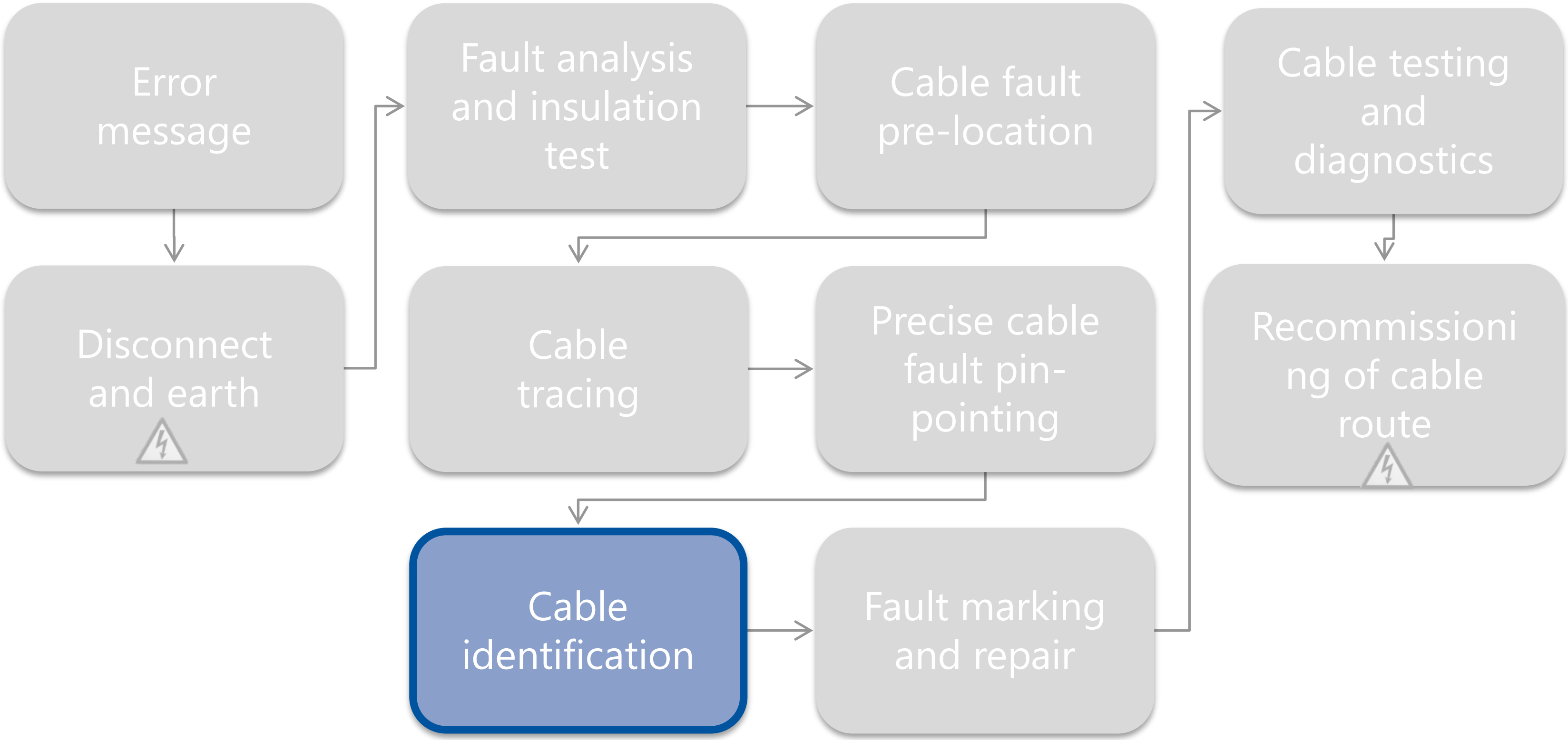
Cable sheath fault to the right of the operator

The first half-wave of the signal has positive polarity.

The increasing signal strength at the bottom of the touchscreen shows that you are moving closer to the cable sheath fault.

"Step voltage" set

Cable identification



Aim of cable identification

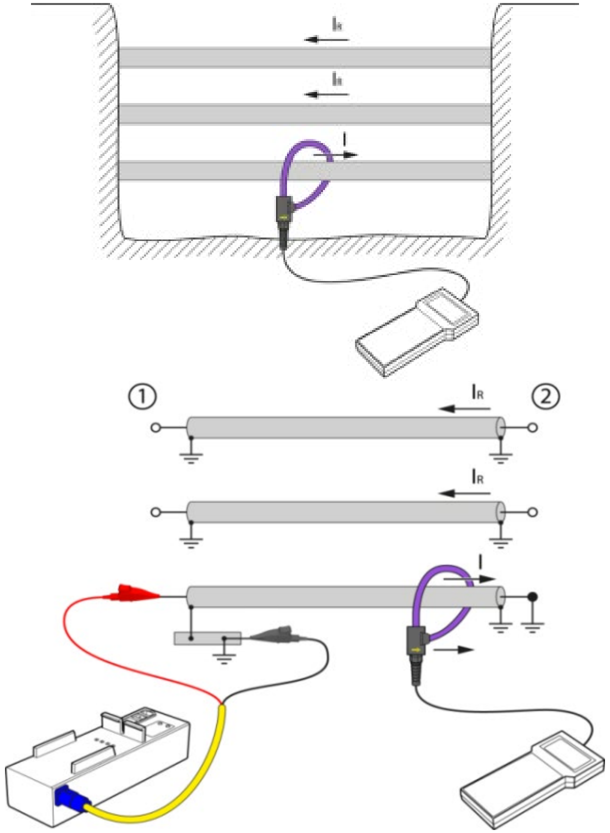
Clear identification of the faulty cable,
e.g. if lots of cables run parallel in the excavation area

Many possible applications

- With flexible Rogowski coil
- For 1- and 3-phase cables

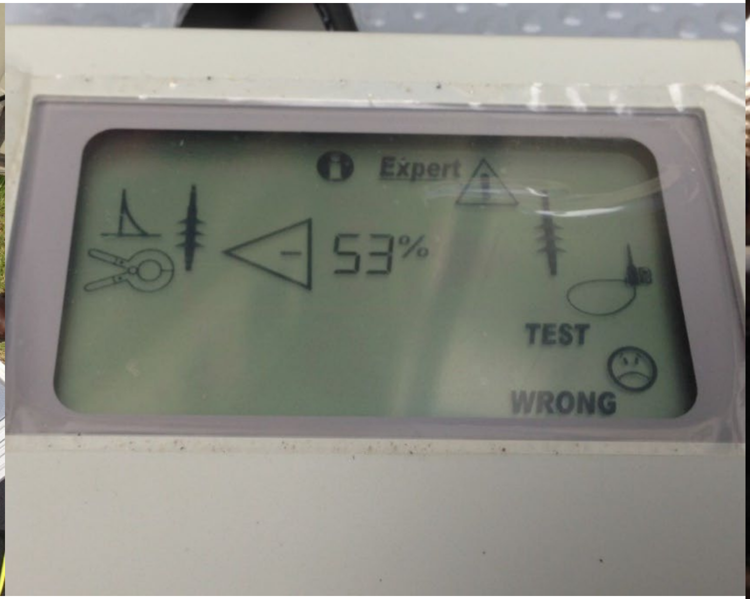
Reliable signal detection through digital analysis of:

- Amplitude
- Phase synchronisation (time)
- Direction (polarity)



ATP to ensure safest signal recognition

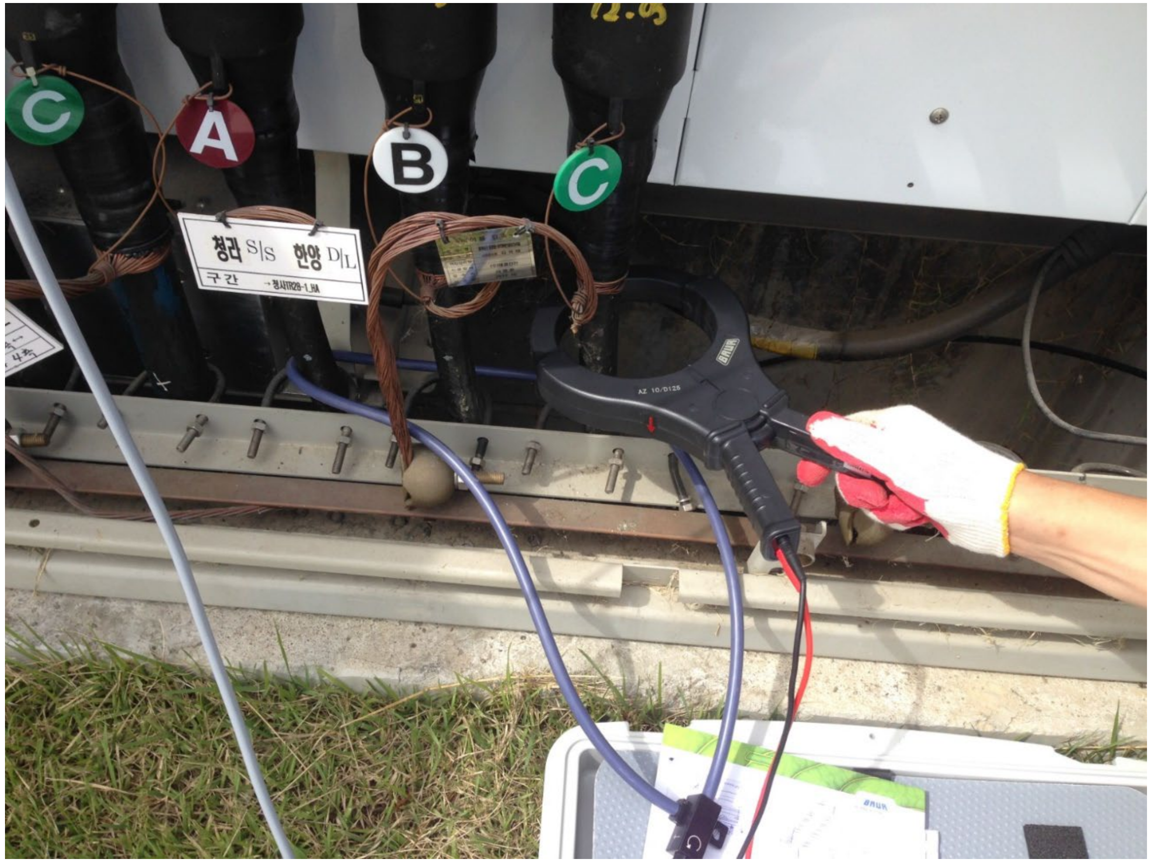
Amplitude
Phase synchronisation (time)
Direction (polarity)



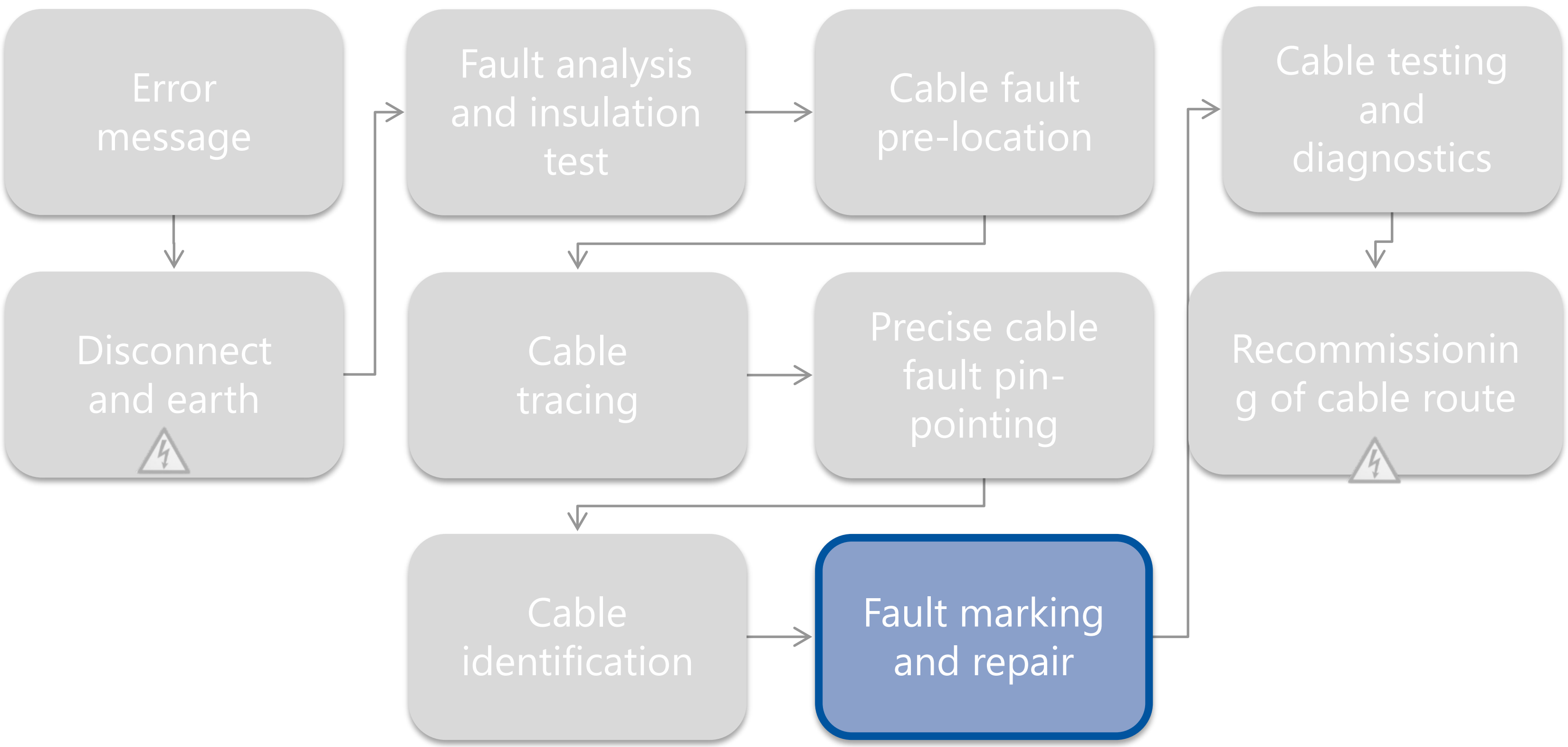
Connections possibility

Connection to live LV cable up to 400V

Signal injection through clamp



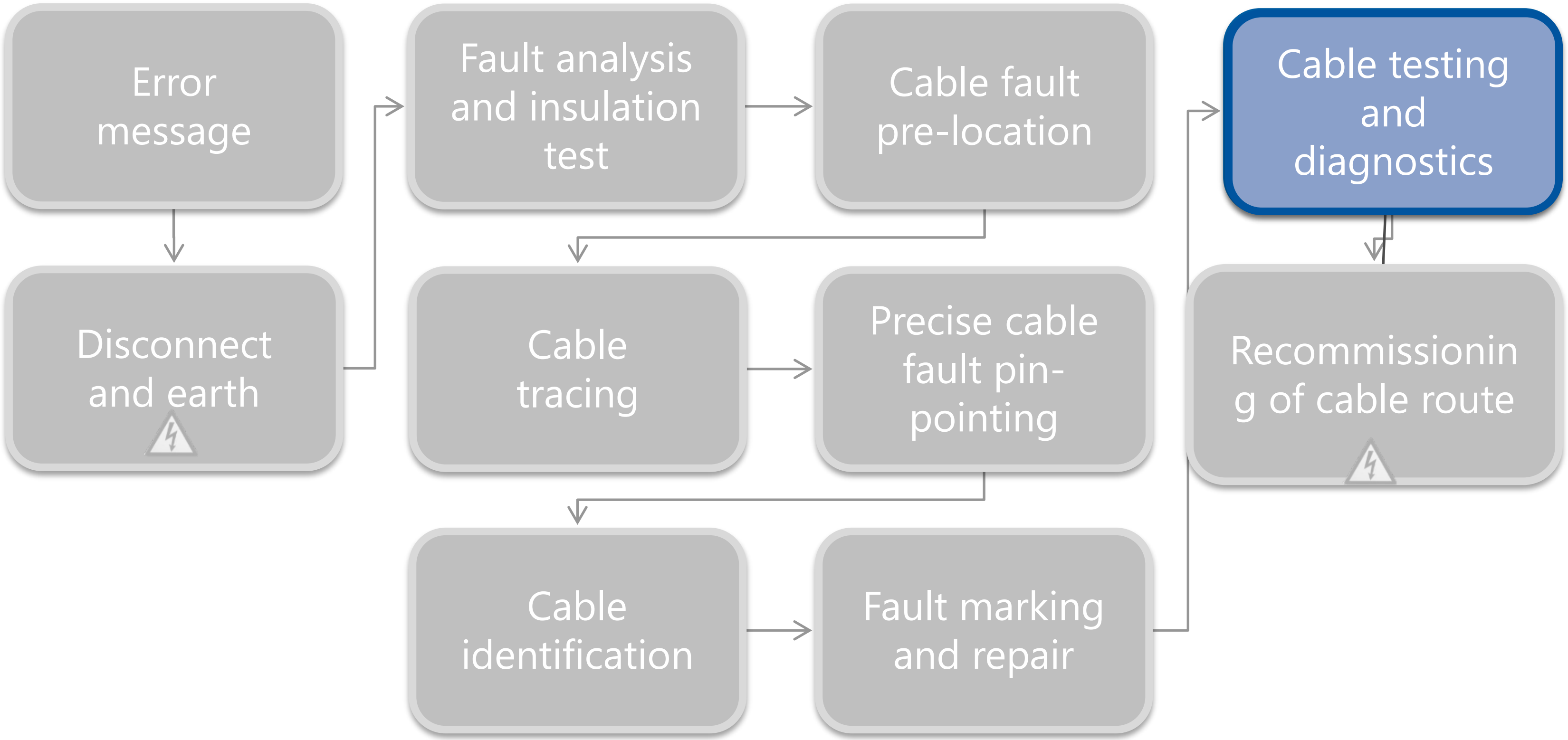
Fault marking and repair



Cable repair

ensuring the flow

Cable testing and diagnostics



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Questions?

ensuring the flow

… since 1945