BAUR
ensuring the flow

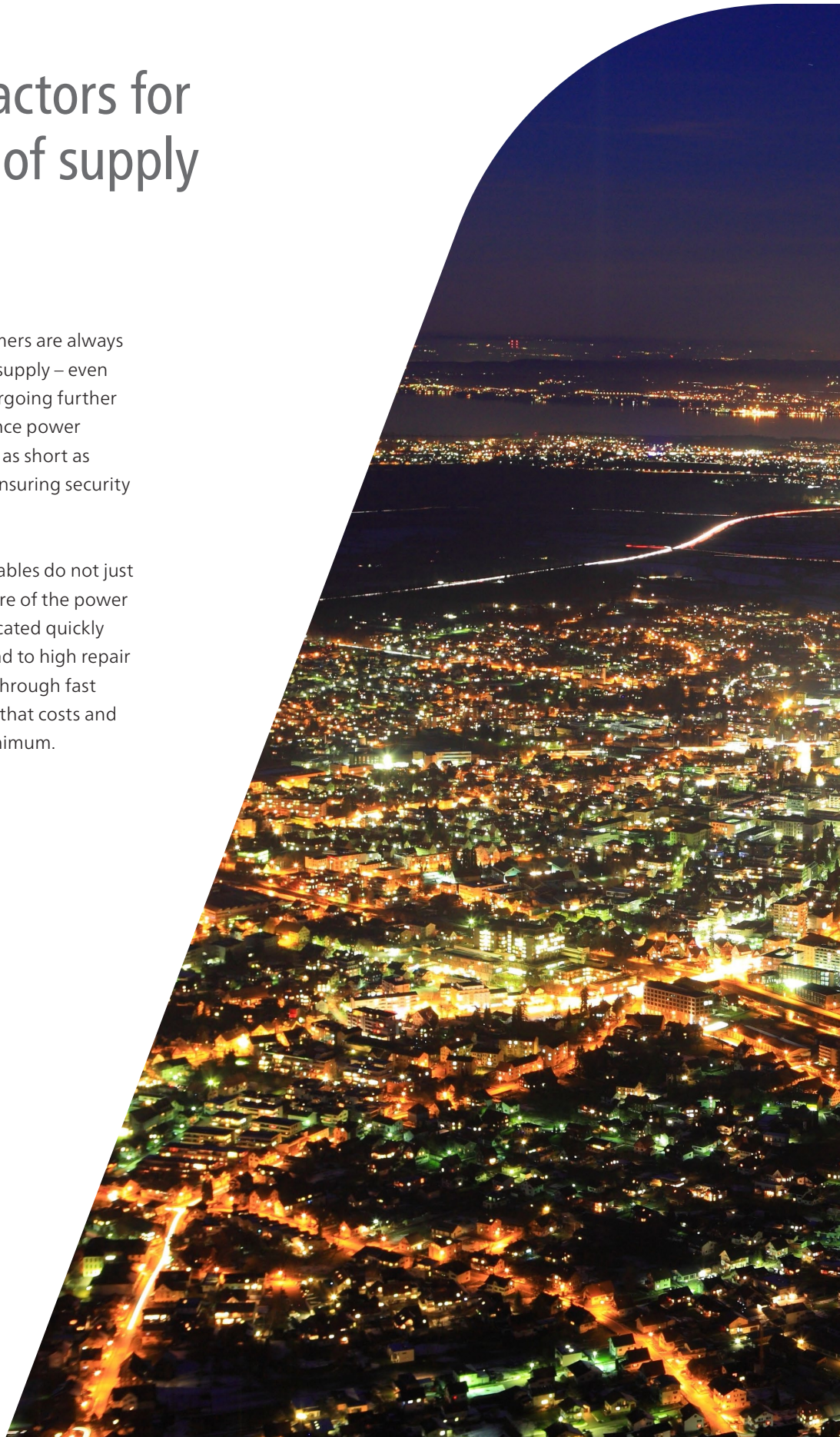
Cable fault location

Locate faults quickly, minimise downtimes

Cables –
the crucial factors for our security of supply

It is essential that energy customers are always provided with a reliable power supply – even when our power supply is undergoing further modification. A high-performance power network, where downtimes are as short as possible, plays a crucial role in ensuring security of supply.

Often, faults on underground cables do not just result in the partial or total failure of the power supply. If these faults are not located quickly and accurately, they can also lead to high repair and restoration costs. It is only through fast and precise cable fault location that costs and downtimes can be kept to a minimum.



BAUR – reliable cable fault location

With BAUR you have an expert partner by your side, enabling you to quickly and accurately locate damage to cables – whatever the application. You can thus provide your customers with a reliable power supply and utilise your resources efficiently. We are dependent on functioning networks – together we can ensure that power keeps flowing.

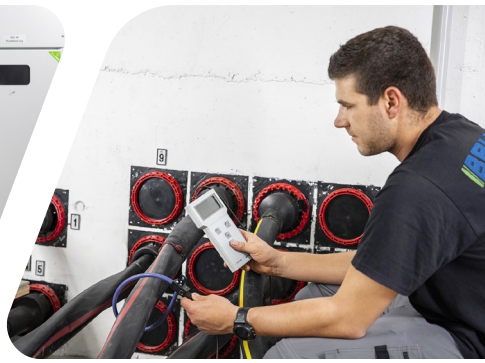
Cable fault location with BAUR – reliability with system

High-quality cable fault location technology from BAUR has been setting a global benchmark for decades. With more than 75 years of experience in cable fault location, we offer application-oriented solutions for measurement engineers to suit all requirements and budgets – with everything available from a single source.

All of the technologies work together in an uncompromising manner, even in one single system. Supported by the new forward-looking software concept, they are easy to use, making it possible for less experienced operators to also use their system in a professional and efficient manner.

Your investment in a reliable network

State-of-the-art fault location technology combined with easy, quick and efficient operation enable problems to be localised and solved as quickly as possible.



Cable fault
Basic conditions, causes and types

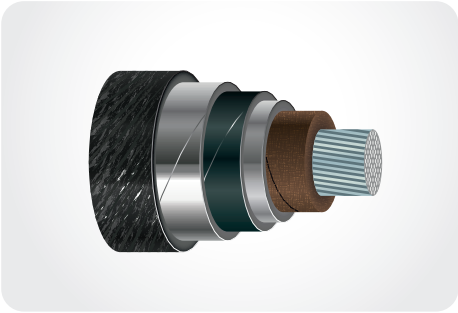
Cable routes are influenced by a variety of ambient parameters. A cable route can consist of multiple diverse cable parts of diverse designs and types. Depending on the voltage level, the required load capacity, and available accessory and installation technology, cables with plastic insulation or mass-impregnated paper insulation are used.

Cable damage can be due to various causes. The most common sources of faults include end of service life and external influences as well as improper assembly. When these types of cable faults occur, the defective spot needs to be detected as quickly as possible and the fault rectified in order to minimise the duration of the failure.

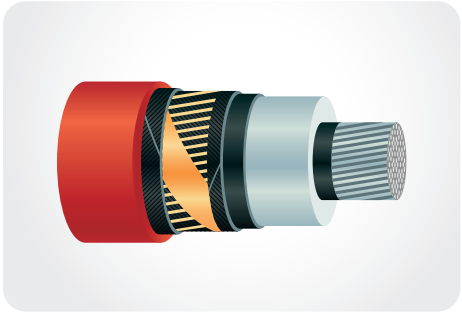
It is helpful if the cable fault location equipment can be used for all voltage levels right across the network. In practice, cable faults must be located on all voltage levels – from low voltage through medium voltage to high voltage.

All from a single source

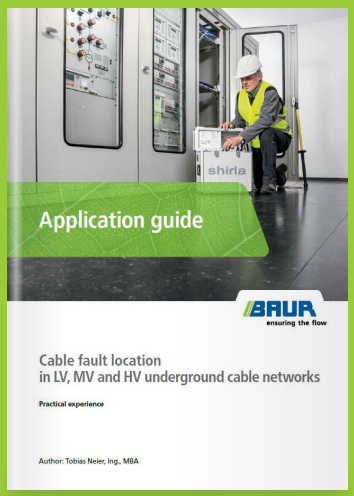
The BAUR device portfolio meets this requirement and satisfies all needs concerning cable fault location, testing, and diagnostics.



← Cables with paper-oil insulation



→ Cables with plastic insulation



Fault types

Short-circuit
Damaged insulation leads to a low-resistance connection of two or more conductors at the fault location.

Earth fault / short-circuit to earth
Earth faults or short-circuits to earth are low-resistive connections to the earth potential. The double earth fault is another type of fault; this fault shows two earth faults on different phases with separated bases.

Cable sheath faults
Damage to the outer cable sheath does not always lead directly to faults. However, it can cause long-term cable faults, among other things, as a result of moisture penetration and insulation damage.

Intermittent faults
Frequently, faults do not occur constantly, but rather occasionally depending on the load on the cable. One reason for this can be drying out of oil-isolated cables with a low load. Another is partial discharge through ageing or electrical trees in cables.

Cable breaks
Mechanical damage and ground movements can lead to breakage of individual or multiple conductors.

Cable fault on paper-insulated mass-impregnated cable

Background knowledge: Cable fault location application guide

Find out more about the background to cable fault location in the “Cable fault location in LV, MV, and HV cable networks” manual from BAUR.

The manual can be downloaded via the media center on our website at:
baur.eu/mediacenter

Process steps and methods of cable fault location

Fault location is carried out methodically following a logical procedure and in four steps.

Fault analysis
Fault analysis makes it possible to determine the characteristics of the fault and the further procedure.

Pre-location
During pre-location, the fault position is determined as precisely as possible.

Tracing and pin-pointing
The objective of the subsequent pin-pointing process is to determine the precise fault location in order to limit excavation work and thus minimise costs and the repair time.

Cable identification
Next comes cable identification, as it is necessary to identify the correct cable among the multiple cables at the fault location. This is especially important if the fault is not visible from outside.

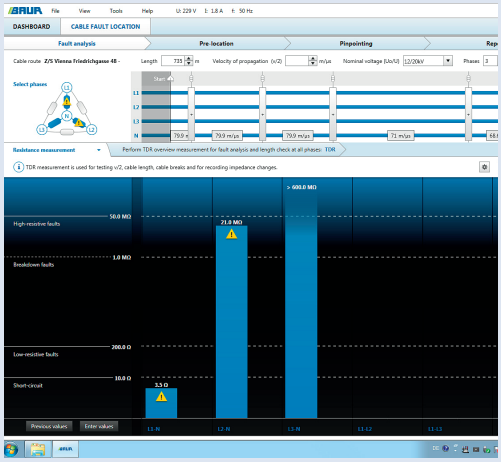
As fast and precise as possible: The right measurement method counts

The objective of fault location is to locate a cable fault as quickly and precisely as possible so as to provide the ideal basis for fast repair and reconnection.

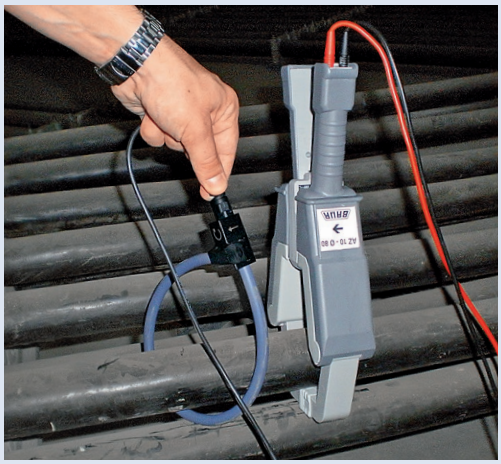
Our devices have a wide spectrum of measurement methods and thus provide you with maximum support in locating the fault. The following double-page spread explains which method is used for which process step.

On page 15 you will find our product function matrix, which provides an overview of the devices and associated measurement methods.

FAULT ANALYSIS



PRE-LOCATION



CABLE IDENTIFICATION

TRACING AND PIN-POINTING

Process steps and methods

FAULT ANALYSIS

Fault analysis is used to ascertain the fault characteristics and determine the subsequent procedure and selection of methods for fault location.

Insulation resistance measurement
to determine the faulty phase and the type of fault.

Cable sheath testing
to detect damage to the outer cable insulation (cable sheath faults).

Voltage test and breakdown detection
to test the dielectric strength of the cable insulation.

PRE-LOCATION

The objective of pre-location is to determine the fault position as precisely as possible so that the subsequent pin-pointing activities can be implemented as quickly and efficiently as possible.

TDR
Time domain reflectometry for locating low-resistive faults and cable breaks, and for determining the cable length

SIM/MIM
The secondary/multiple impulse method is the most well-established and precise cable fault pre-location method. High-resistive faults and breakdown faults are ignited by a single HV pulse and the fault distance is measured very precisely several times via the TDR technology and automatically evaluated.

DC-SIM/MIM
Secondary/multiple impulse method in DC mode for pin-pointing intermittent faults. DC voltage is applied to the cable until breakdown. The cable capacitance is used to increase the available surge energy.

Conditioning-SIM/MIM
Difficult to locate or wet faults are first conditioned with surge voltage before a SIM/MIM measurement is carried out.

Decay
Voltage-coupled decay method for locating breakdown faults with high voltage. The oscillating voltage reflection waves are evaluated automatically to determine the fault distance.

ICM
Impulse current method for locating high-resistive faults and breakdown faults. The fault distance is determined by analysing the impulse current diagram. Particularly suitable for use on long cables.

DC-ICM
Impulse current method used in DC mode for locating chargeable breakdown faults for which the cable capacitance is used in conjunction with a surge voltage generator.

Measurement mode with envelope curve display
In this process, even small, intermittent changes to impedance can be made visible by means of an envelope curve and saved automatically.

TRACING AND PIN-POINTING

As precise as pre-location is, it is never able to detect or recognise the existing deviations of a cable route in the ground. These can only be detected by precise pin-pointing.

Acoustic pin-pointing
is the most common method used to determine the precise location of high-resistive faults and breakdown faults. High-voltage pulses create electromagnetic pulses on the way to the fault location and generate a breakdown with an audible bang.

Step voltage method
to determine the precise location of cable sheath faults. A voltage drop is generated at the fault which can be located using earth spikes and a receiver.

Tracing
to precisely determine the cable route. Precise cable tracing is essential, particularly with unknown or imprecise cable routes, and saves both time and money.

Twist method or minimum distortion method
used when pin-pointing short-circuits depending on the cable type. In this process, the disturbance in the otherwise homogeneous magnetic field that is caused by the fault is measured and located precisely.

CABLE IDENTIFICATION

Usually, multiple cables are laid in a cable route. Once the exact position of the fault has been determined and exposed, the defective cable must be identified reliably.

Cable identification
is used to identify single- and multi-core cables in a cable loom. The measurement engineer is provided with precise information as to which cable needs to be tested and, where necessary, cut.

Appropriate solutions from BAUR for every measurement method
from page 14 onwards

BAUR measurement and test equipment
Hardware and software


shirla

Product overview

Technical information and data sheets for each of our products is available at **baur.eu/cfl**

Our products reflect our 75 plus years of expertise. The BAUR device portfolio for cable fault location covers the entire process in an optimum manner and helps the operator locate faults quickly and reliably. Modular systems and devices are perfectly customised to your individual requirements. Convincing flexibility!

01 / Portable devices

Our portable devices convince with their highest level of precision, easy handling and unlimited mobility.

02 / High-performance modules

BAUR offers a diverse portfolio of modules, enabling you to configure a custom package for your cable fault location needs.

03 / System solutions

With the Syscompact series, BAUR offers compact, robust, small systems that are adapted to fault location tasks.

04 / Cable test vans

Our cable fault location systems are equipped according to your requirements, enabling you to combine the complete product range for cable fault location, testing, and diagnostics in a single system. There are fully-automatic and semi-automatic systems, each with either 1 or 3 phases.

↑ **01 /** protrac® pin-pointing system

↑ **01 /** shirla sheath test and fault location device

↑ **01 /** KSG 200 cable identification system

↑ **02 /** IRG 400 portable time domain reflectometer

↑ **02 /** SSG surge voltage generators

↑ **02 /** ATG 6000 burn down transformer

↑ **03 /** Syscompact 400 portable cable fault location system

↑ **03 /** Syscompact 400 portable fault location system

↑ **03 /** Syscompact 4000 cable fault location system

↑ **04 /** titron® **cable test van**

↑ **04 /** transcable cable test van

Product function matrix

	Products	Application / measurement methods: Pre-location: Time domain reflectometry (TDR)	Pre-location: TDR with envelope curve display	Pre-location: SIM/MIM secondary/multiple impulse method	Pre-location: Conditioning-SIM/MIM	Pre-location: ICM impulse current method	Pre-location: DC-SIM/MIM	Pre-location: Decay method	Pre-location: DC-ICM	Pre-location: 3-phase current coupling methods	Pre-location: Fault conditioning/burn	Pre-location: Sheath fault pre-location	Testing: Insulation measurement	Testing: Voltage withstand test for breakdown detection	Testing: Cable sheath testing	Pin-pointing: Audio frequency methods (twist field & minimum distortion method)	Pin-pointing: Acoustic pin-pointing	Pin-pointing: Step voltage or voltage drop method	Pin-pointing: Tracing	Identification: Cable identification	Identification: Phase identification	Application: Medium voltage	Application: Low voltage	Application: High Voltage	Application: Telecom and control cables
Devices	IRG 4000 portable time domain reflectometer	■	■	□	□	□	□	□	□	□			■									■	■	■	■
	IRG 400 portable time domain reflectometer	■																				■	■	■	■
	SSG surge voltage generator																■					■	■		
	protrac® pin-pointing system																■	■	■			■	■	■	
	ATG burn down transformers										■											■	■		
	shirla sheath test and fault location device											■			■			■				■	■	■	■
	KSG 200 cable identification system																			■		■	■	■	■
	CL 20 cable locator															■			■			■	■	■	■
Systems	titron® cable test van	■	■	■	■	■	■	■	■	■	□		■	■	■	□	□	□	□			■	■	■	■
	transcable cable test van	■		■		■	■	■	■	■	□		□	■	■	□	□	□	□			■	■	■	■
	Syscompact 4000 cable fault location system	■		■		■	■		■				□	■	■	□	□	□	□			■	■	■	■
	Syscompact 400 cable fault location system	■		■		■	■	■	■		■			■	■	□	□	□	□			■	■	■	■
	Syscompact 400 portable portable cable fault location system	■		■		■	■	■	■		■			■	■	□	□	□	□			■	■	■	■

■ ■ Basic configuration □ □ Option

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 18

Control cables

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

PAGE 19

Low-voltage cables

… transport voltage up to 1 kV.

PAGE 20

Medium-voltage cables

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

PAGE 21

High-voltage cables

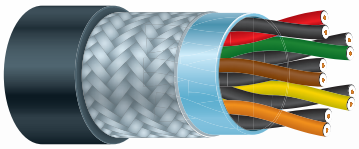
… transport voltage from 36 kV (country-specific).

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.

Solutions for control cables



FAULT ANALYSIS

	Products
Sheath testing	01, 06

PRE-LOCATION

	Products
TDR	02, 07
Bridge measurement	01

CABLE IDENTIFICATION

	Products
Cable identification with pulsed DC voltage	05
Cable identification with AC voltage	04

TRACING AND PIN-POINTING

	Products
Tracing	03, 05
Step voltage method	01, 03
Twist method	03, 04

Products

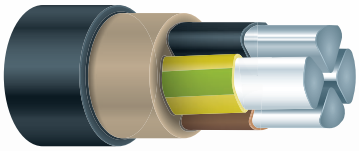
01 / shirla sheath test and fault location device

02 / IRG 400 portable time domain reflectometer

03 / protrac® pin-pointing system

04 / CL 20 cable locator

Solutions for low-voltage cables



FAULT ANALYSIS

	Products
Insulation resistance measurement	06, 07
Voltage test	01, 06
Sheath testing	01, 06

PRE-LOCATION

	Products
TDR	02, 06, 07
SIM/MIM	06, 07
Bridge measurement	01
Differential methods	02, 06, 07

CABLE IDENTIFICATION

	Products
Cable identification with pulsed DC voltage	05
Cable identification with AC voltage	03

TRACING AND PIN-POINTING

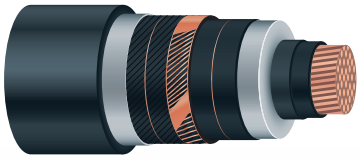
	Products
Tracing	04
Step voltage method	01
Twist method	04
Acoustic pin-pointing	03, 06

05 / KSG 200 cable identification system

06 / Syscompact 400 portable cable fault location system

07 / Time domain reflectormeter IRG 4000 portable

Solutions for medium-voltage cables



FAULT ANALYSIS

	Products
Insulation resistance measurement	02, 03, 04, 05, 10
Breakdown voltage detection	02, 03, 04, 05
Sheath testing	01, 02, 03, 04, 05

PRE-LOCATION

	Products
TDR	02, 03, 04, 05, 10
SIM/MIM	02, 03, 04, 05, 10
DC-SIM/MIM	02, 03, 04, 05, 10
Conditioning-SIM/MIM	02, 03, 04, 05, 10
ICM and DC-ICM	02, 03, 04, 05, 10
Decay	02, 03, 04, 05, 09,10
Bridge measurement	01
Differential methods	02, 03, 04, 05, 10

CABLE IDENTIFICATION

	Products
Cable identification with pulsed DC voltage	09
Cable identification with AC voltage	07

TRACING AND PIN-POINTING

	Products
Tracing	06, 07
Step voltage method	01, 02, 04, 05, 07
Twist method (for belted cables only)	04, 05, 06, 07
Minimum distortion method	04, 05, 06, 07
Acoustic pin-pointing	02, 04, 05, 07

Products

01 / shirla sheath test and fault location device

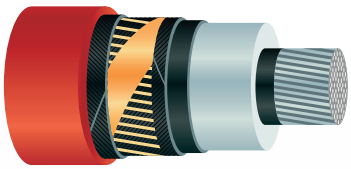
02 / Syscompact 4000 cable fault location system incl. HV source

03 / Syscompact 400 portable cable fault location system

04 / titron® cable test van

05 / transcable cable test van

Solutions for high-voltage cables



FAULT ANALYSIS

	Products
Insulation resistance measurement	02, 03, 04, 05, 09, 10
Breakdown voltage detection	02, 03, 04, 05, 09
Sheath testing	01, 02, 03, 04, 05

PRE-LOCATION

	Products
TDR	02, 03, 04, 05, 10
SIM/MIM	02, 03, 04, 05, 10
DC-SIM/MIM	02, 03, 04, 05, 10
Conditioning-SIM/MIM	02, 03, 04, 05, 10
ICM and DC-ICM	02, 03, 04, 05, 10
Decay	02, 03, 04, 05, 10
Bridge measurement	01
Differential methods	02, 03, 04, 05, 10

CABLE IDENTIFICATION

	Products
Cable identification with pulsed DC voltage	08
Cable identification with AC voltage	07

TRACING AND PIN-POINTING

	Products
Tracing	06, 07
Step voltage method	01, 02, 04, 05, 07
Minimum distortion method	04, 05, 06
Acoustic pin-pointing	02, 04, 05, 07

06 / CL 20 cable locator

07 / protrac® pin-pointing system

08 / KSG 200 cable identification system

09 / PGK 260 HB AC/DC HV test set

10 / Time domain reflectormeter IRG 4000 portable

Solutions for XL-CFL

Long submarine and land cables

FAULT ANALYSIS

	Products
Insulation resistance measurement	02, 03, 04, 08, 09
Breakdown voltage detection	02, 03, 04, 08
Sheath testing	01, 02, 03, 04, 05

PRE-LOCATION

	Products
TDR	02, 03, 04, 08,09
SIM/MIM	02, 03, 04, 08,09
DC-SIM/MIM	02, 03, 04, 08,09
Conditioning-SIM/MIM	02, 03, 04, 08,09
ICM and DC-ICM	02, 03, 04, 08,09
Decay	02, 03, 04, 08,09
Bridge measurement	01
Differential method	02, 03, 04, 09

CABLE IDENTIFICATION

	Products
Cable identification with pulsed DC voltage	07
Cable identification with AC voltage	06

TRACING AND PIN-POINTING

	Products
Tracing	05, 06
Step voltage method	06
Minimum distortion method	05, 06
Acoustic pin-pointing	06

The XL-CFL systems are tailored to the system-specific requirements. This includes: ■ Marine-grade containers ■ Hermetically sealed HV and operating areas ■ Air conditioning system for maritime climate, also for excess pressure in the container ■ Screen to protect against spray ■ Discharge unit adapted to the system size ■ Pressure relief according to the spatial volume and possible arcing faults ■ Appropriately dimensioned earthing cross sections

All devices and functions can be installed in customer-specific container solutions.

01 / shirla sheath test and fault location device

02 / Syscompact 4000 cable fault location system incl. HV source

03 / titron cable test van

04 / transcable cable test van

05 / CL 20 cable locator

06 / protrac® pin-pointing system

07 / KSG 200 cable identification system

08 / PGK 260 HB AC/DC HV test set

09 / Time domain reflectometer IRG 4000 portable

Long submarine and land cables for global power supply

Indispensable and robust, but sadly not indestructible.

Submarine power cables are indispensable for reliable power supply. Among experts, submarine cables are actually classified as critical infrastructure. This is on account of the harsh installation environment and mechanical stress caused by currents, fishing, and anchors.

BAUR XL-CFL solutions are specifically designed for effective and precise cable fault location on long submarine and land cables. Contact us to discuss your custom solution package.

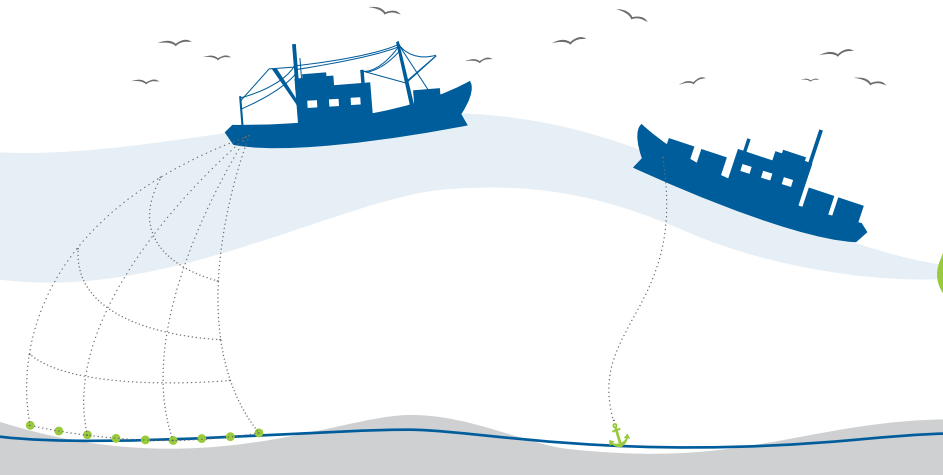
The impact of cable faults enters a new dimension

When a submarine cable is damaged, cable fault location and repair is usually a complex and time-consuming process. The protracted downtime translates into losses in the millions for the cable operator – with the downtime costs growing day on day!

Many cable operators therefore invest in a suitable fault location system even before the cable is put into operation. Immediate availability when a fault occurs means that the fault can be located straight away, thus reducing cable downtime in the long term.

More stringent safety requirements cannot be met with traditional cable fault location

Depending on the fault type and breakdown voltage, high voltage may be used for cable testing and cable fault location. Long cables store a lot of energy during this process. Most devices and measurement systems are unable to cope with the discharge of this high level of energy, which ultimately causes damage to the devices and poses a danger to operating personnel. You should therefore rely on proven BAUR solutions from the outset that are specifically designed for long land and submarine cables.



The biggest threats to submarine cables:
External forces exerted by heavy ships' anchors and trawl nets of fishing boats at all sea depths.

Submarine cable
Seabed

BAUR Software 4 –
for intuitive cable fault location

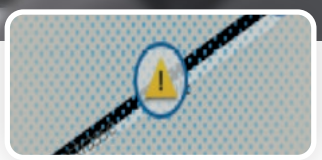
The BAUR Software 4 covers all the solutions for cable fault location, cable testing, and cable diagnostics, ensuring efficient and precise condition monitoring for cable networks when used in conjunction with BAUR hardware. It includes well-established measurement methods for cable fault location as well as innovative approaches such as Conditioning-SIM/MIM, enabling even faster and more effective localisation of wet cable faults that are difficult to locate.

The BAUR Software 4 scope of performance far exceeds standard features; the operator is also assisted by the intuitive operational concept and helpful support functions.

Connect and go – the new operational concept

- Intuitive modern user interface – no lengthy period of familiarisation
- Automated sequences for fast and reliable cable fault location
- Optimum operator support during cable fault location provided by the Smart Cable Fault Location Guide
- BAUR GeoBase Map*:
  - Unique combination of road maps, including the cable route
  - GPS-based system location determination
  - Cable routes and cable faults displayed on the map
- Cable Mapping Technology CMT: Overview of cable accessories and faults in relation to the cable length
- All data on the cable route such as geographic position, voltage level, joints, all measured values, etc. are automatically saved and can be accessed at any time.
- Fast and easy compilation of clear and precise measurement logs – with freely selectable company logo, comments, and figures of the traces.
- Import and export of measurement data with available cable route data

The BAUR Software 4 display enables clear visualisation of all important settings, fault location parameters, and cable data. The bottom part of the screen shows the measurement results and allows important events to be logged straight away.

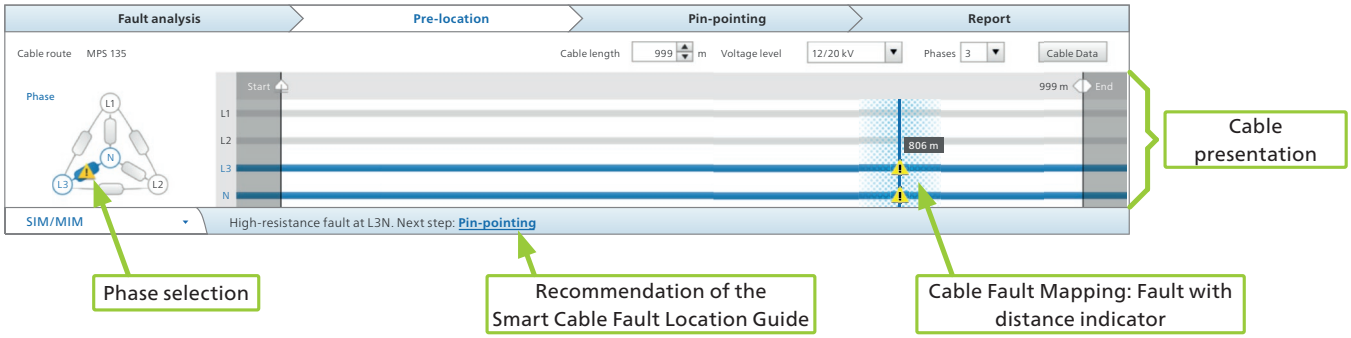


Clear visualisation of cable faults with BAUR Mapping

Step-by-step process with the Smart Cable Fault Location Guide

- The Smart Cable Fault Location Guide leads the operator to the cable fault quickly and efficiently.
- A special algorithm continuously analyses the current measurement results, which it then uses to generate optimum recommendations for how the operator should proceed in order to reliably locate the cable fault.
- Automatic fault analysis with clear graphical presentation for a better overview.
- Test voltage assistant:
  - The system recommends voltage values according to the cable data and the fault type
  - The test voltages can be defined on a user-specific basis
- Automatic cursor positioning at the cable end and at the fault location
- Automatic settings of method-related parameters for fast and efficient fault location
- Clear graphical presentation of the measurement results with helpful functions for evaluation

All this with full flexibility for experienced operators! Experienced measurement engineers can draw on their expertise at any point during the measurement process and select their user-specific procedure.



BAUR Fault Location App

Non-destructive and safe pin-pointing

Supported devices

- iPhone, iPad, iPad mini, iPod touch (from iOS version 9.2 onwards)
- Smartphones or tablets with Android operating system (from version 4.0.3 onwards)

Remote control of titron® via smartphone or tablet

During pin-pointing, all the essential functions of titron® can be controlled remotely via the BAUR Fault Location App:

- Switching the surge voltage generator on and off
- Setting the surge voltage and surge sequence (5 – 20 pulses/min, single surge)
- Selecting the surge voltage range

This way, the operator has the possibility of only switching on the high voltage when he reaches the pre-located fault location. Once the fault has been located, the high voltage can be switched off again. Through this, the stress on the cable and the system is reduced to the necessary minimum and the level of safety is significantly increased.

Location and fault position at a glance

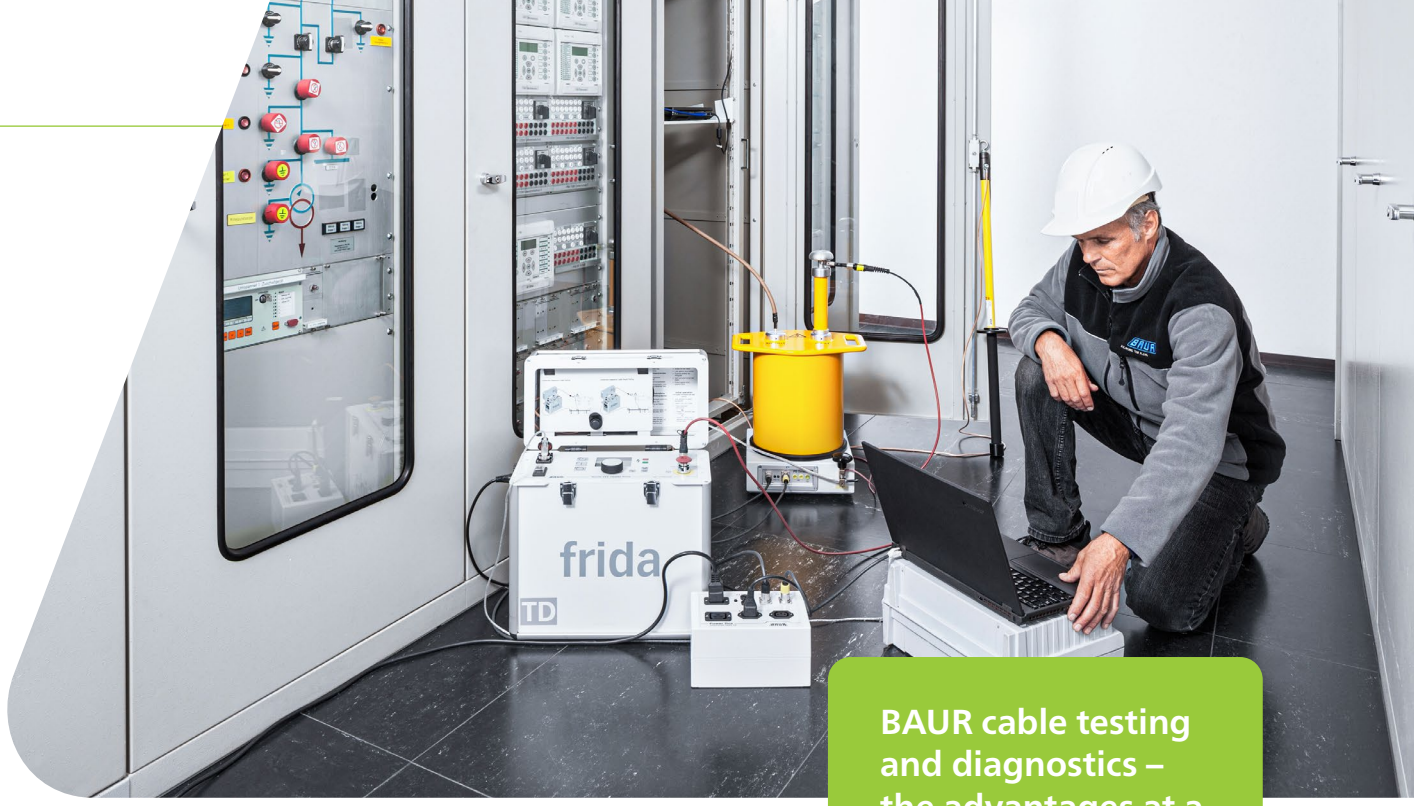
The cable data is transmitted from the cable fault location system to the Fault Location App and is displayed in the app in combination with the road map. This allows the operator always to have the latest information on the

- Cable route (if available)
- Pre-located fault position
- Location of the cable test van

Monitoring and adjusting the measurement parameters during the fault location

In the fault location mode, the operator always has an overview of the most important measurement parameters:

- High-voltage status
- Output voltage, max. permissible voltage
- Surge sequence, surge energy, duration of the measurement
- SSG capacitor charge and discharge curve



BAUR cable testing and diagnostics – the advantages at a glance:

- Reliable and precise cable diagnostics
- More efficient workflow – tailored to every power supply company
- Reduced maintenance costs
- Optimum balance between network availability and cost efficiency

home of **diagnostics**

BAUR enables cost-optimised maintenance

Along with measuring devices for precise cable fault location, BAUR also offers solutions for easy and efficient condition evaluation of cables. More and more network operators emphasise the importance of cable diagnostics, as it provides important information on the hidden faults in systems and, in particular, the cable network. With cable diagnostics, you will solve the problem of providing maximum network availability whilst keeping maintenance costs to a minimum. Failures can thus be prevented and investments planned more effectively.

Extensive measurement and testing expertise under one roof

At BAUR, the "home of diagnostics", every measurement engineer and asset manager can feel more assured than ever before when it comes to realising the objective of planning repairs in a proactive and cost-optimised way. Several factors come into play here:

BAUR measurement technology

The BAUR portfolio covers all the important requirements of network operators with regard to testing and diagnostics technology in the medium voltage range.

Evaluation with BAUR Software 4

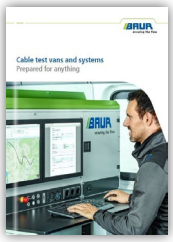
The intuitive BAUR Software 4 guides measurement engineers through the process of cable testing and diagnostic measurements, combining the two in an efficient workflow that saves time.

Life time estimation with BAUR statex®

The patented statex® algorithm enables accurate assessment of the condition and remaining life time of cables. This means that existing cables can be used for a longer period of time, reducing investment costs significantly.

Other BAUR Brochures

Cable testing and diagnostics

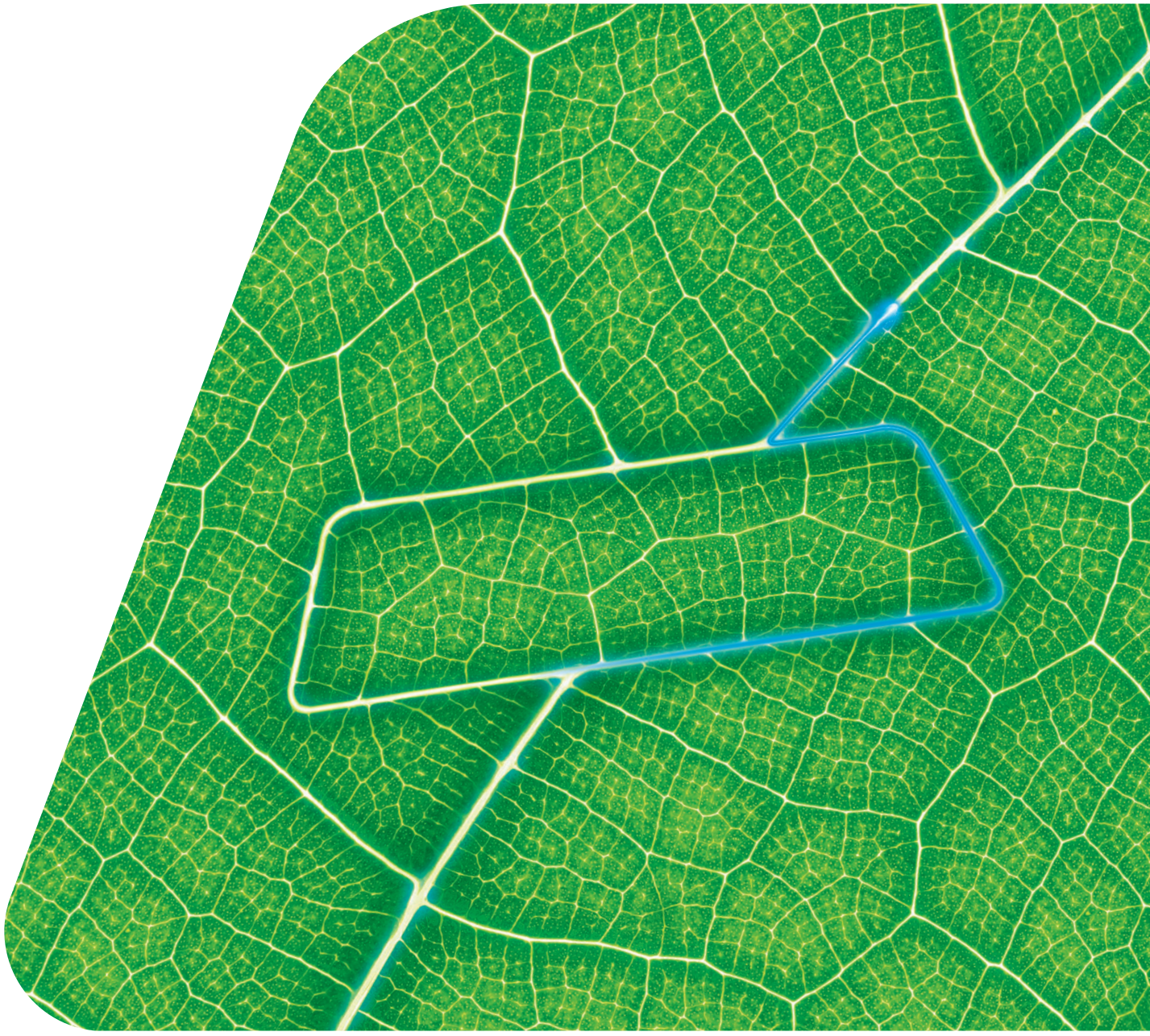


Cable test vans and systems

Insulating oil testing

Product overview

Further product information is available at:
baur.eu/brochures



BAUR GmbH · Raiffeisenstraße 8 · 6832 Sulz · Austria
T +43 5522 4941-0 · headoffice@baur.eu · www.baur.eu

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