PSOS Guest Lecture

5.11.2024

HORSTMANN
GERMANY

Horstmann

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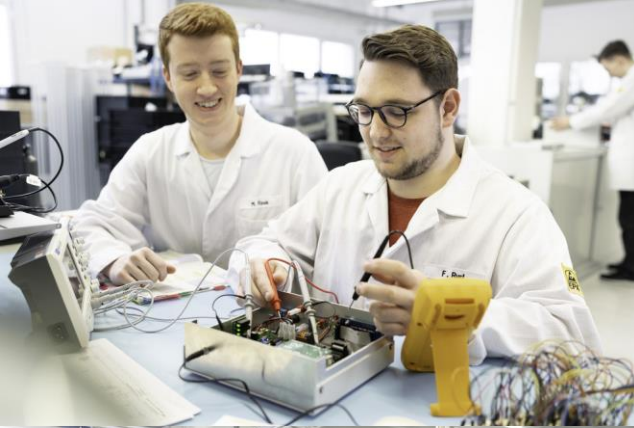GERMANY

Horstmann at a glance

77 years of experience with products and solutions for electrical distribution grids / energy suppliers

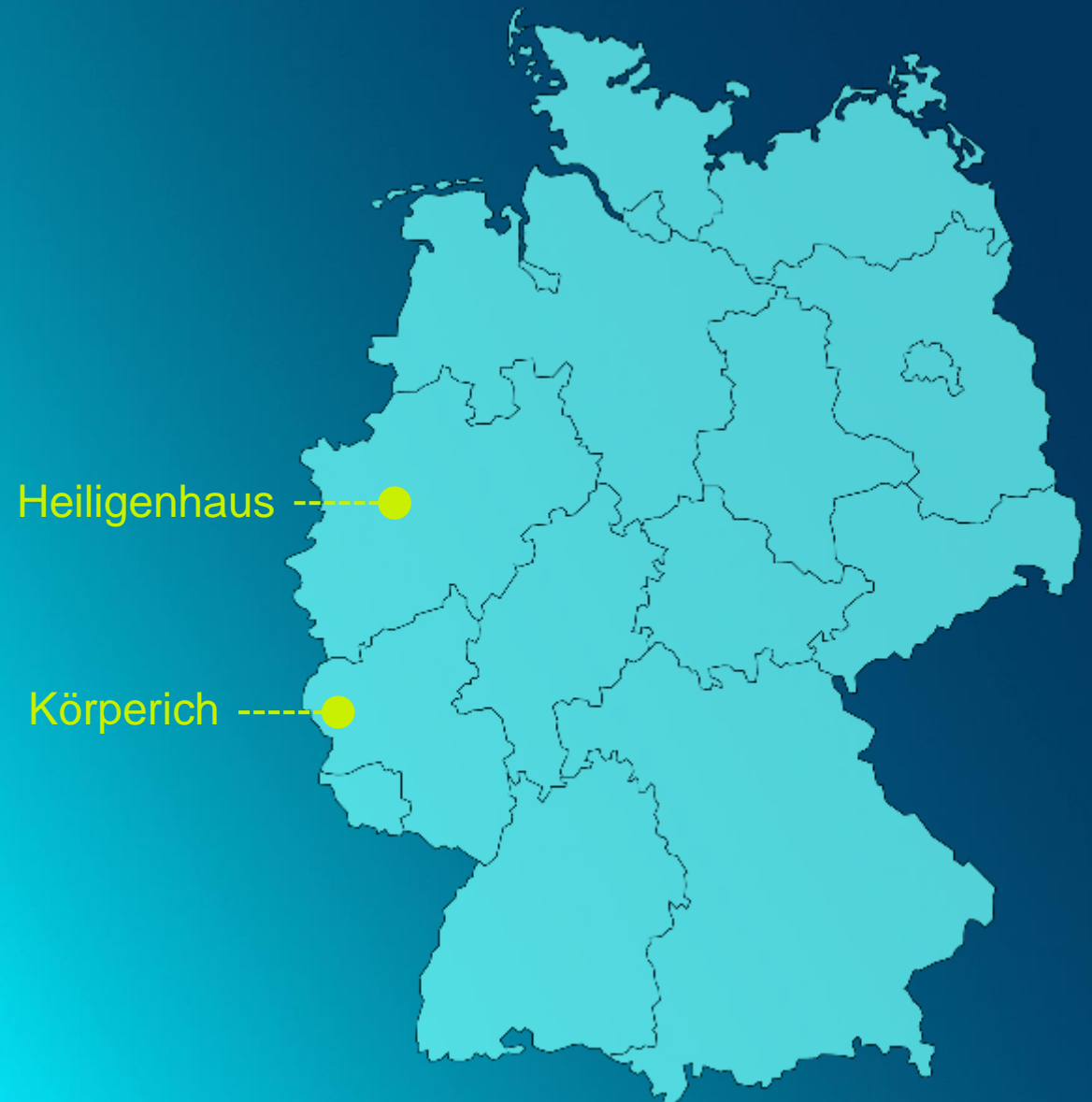**Family-run company** in the third generation (Heinrich Horstmann Heiligenhaus)

Inventor of the short-circuit indicator and market leader in the distribution grid monitoring segment

>270 employees at two locations → production in Germany

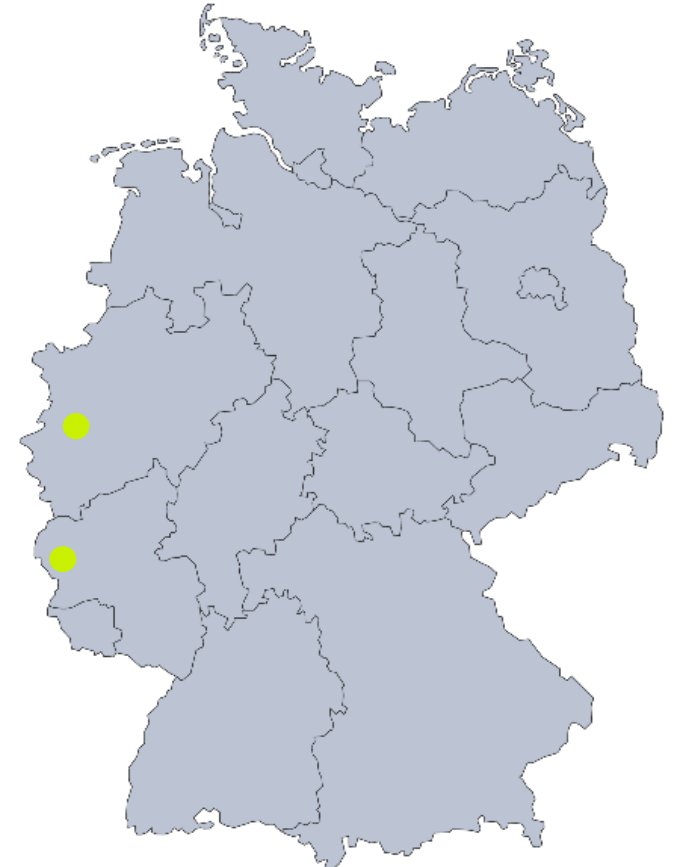**Worldwide sales and service**, quality and reliability - MADE IN GERMANY

Heiligenhaus

Körperich

HHH HORSTMANN
GERMANY

Horstmann locations

Head office

Humboldtstraße 2–10

42579 Heiligenhaus

Second plant

Bergstraße 1

54675 Körperich

HHH **HORSTMANN** GERMANY

State-of-the-art production facilities

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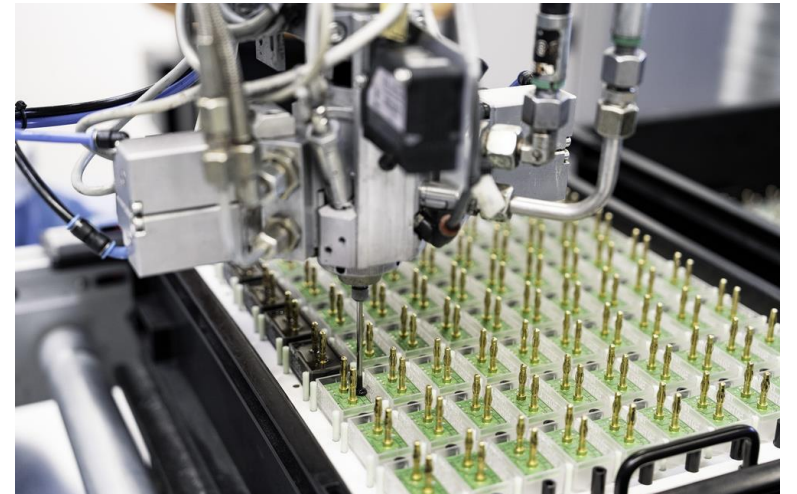
Extensive quality assurance, testing and inspection facilities

- ▸ Test laboratory
- ▸ EMC test equipment
- ▸ Primary test fields high voltage and current
- ▸ Environmental simulations and climate tests
- ▸ 100% routine testing, primary testing, and quality control to the goods issue

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Representatives and service worldwide

Guest Lecture PSOS | HHH | English | © Dipl.-Ing. H. Horstmann GmbH | 2024
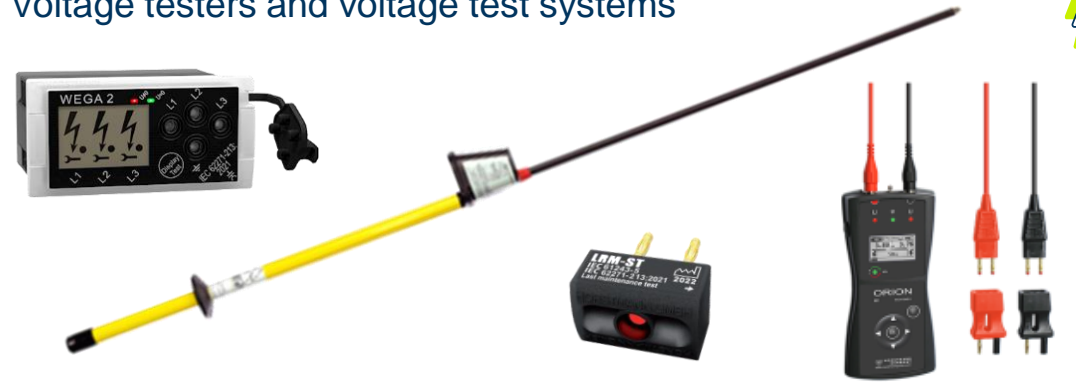
Product and system solutions

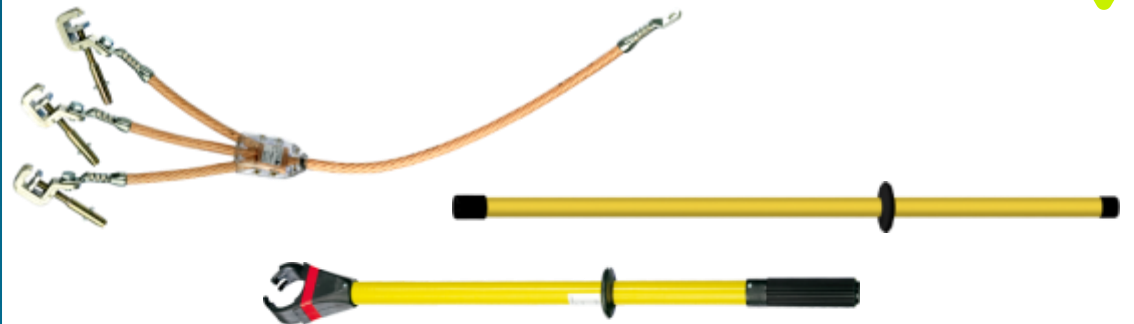## Short and earth fault indicators

Voltage testers and voltage test systems

Solutions for monitoring, telecommunication and visualization

Grounding devices and station accessories

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Digitization of distribution grids

motivation

Stromausfall in Ludwigsburg: Bagger verursacht einen Erdschluss

von Carolin Schneider | 06.03.2023, 18:27 Uhr

Eine Baggerschaufel beschädigte das Kabel in der Friesenstraße. Dadurch kam es zum Erdschluss. Foto: Oliver Boehmer/stock-adobe.com

source: Stromausfall in Ludwigsburg: Bagger verursacht einen Erdschluss (lkz.de)

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Lecture Recap: Hierarchical grid structure

- **Transmission grid**

- **Sub-Transmission grid**

- **Distribution grid**

380/220 kV

110 kV

110 kV

10 kV

10 kV

V V

400 V

PSOS Lecture
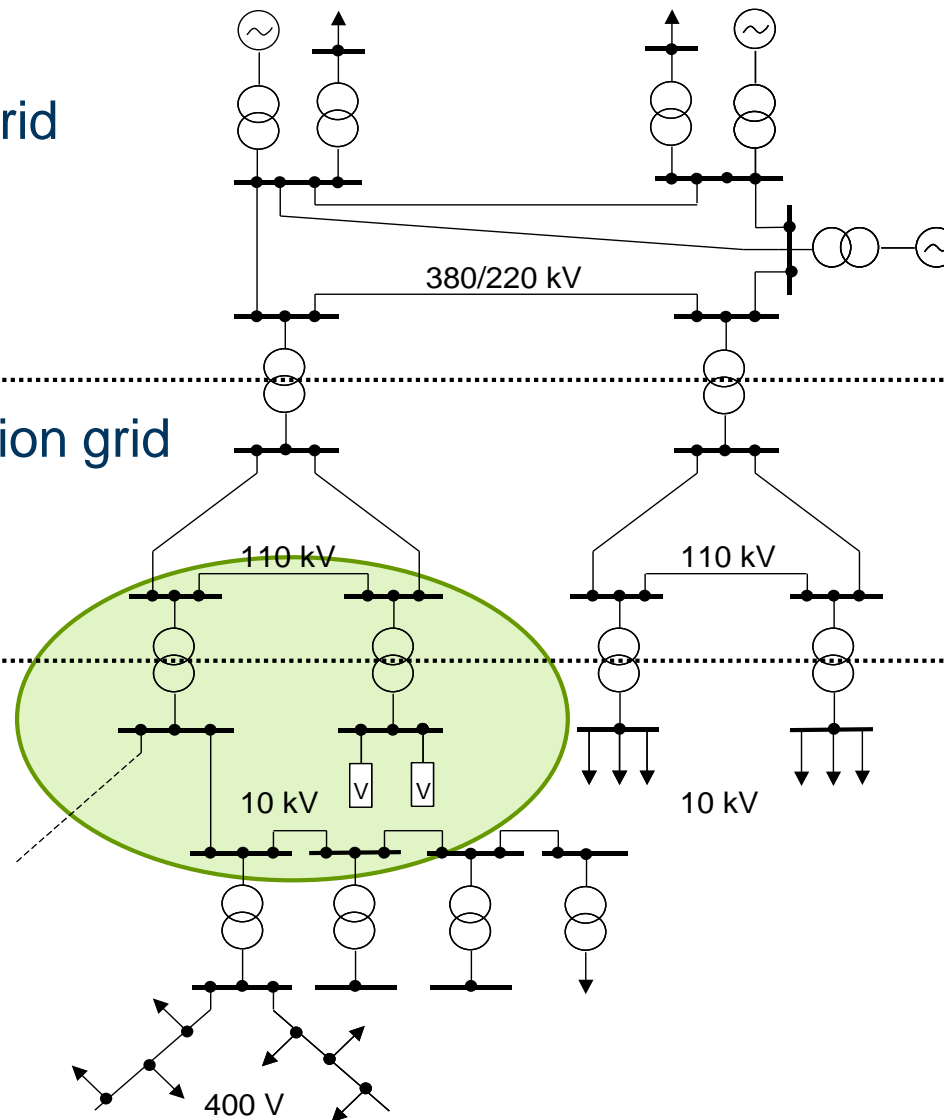
Lecture recap: Number of Faults per Year and 100 km Line
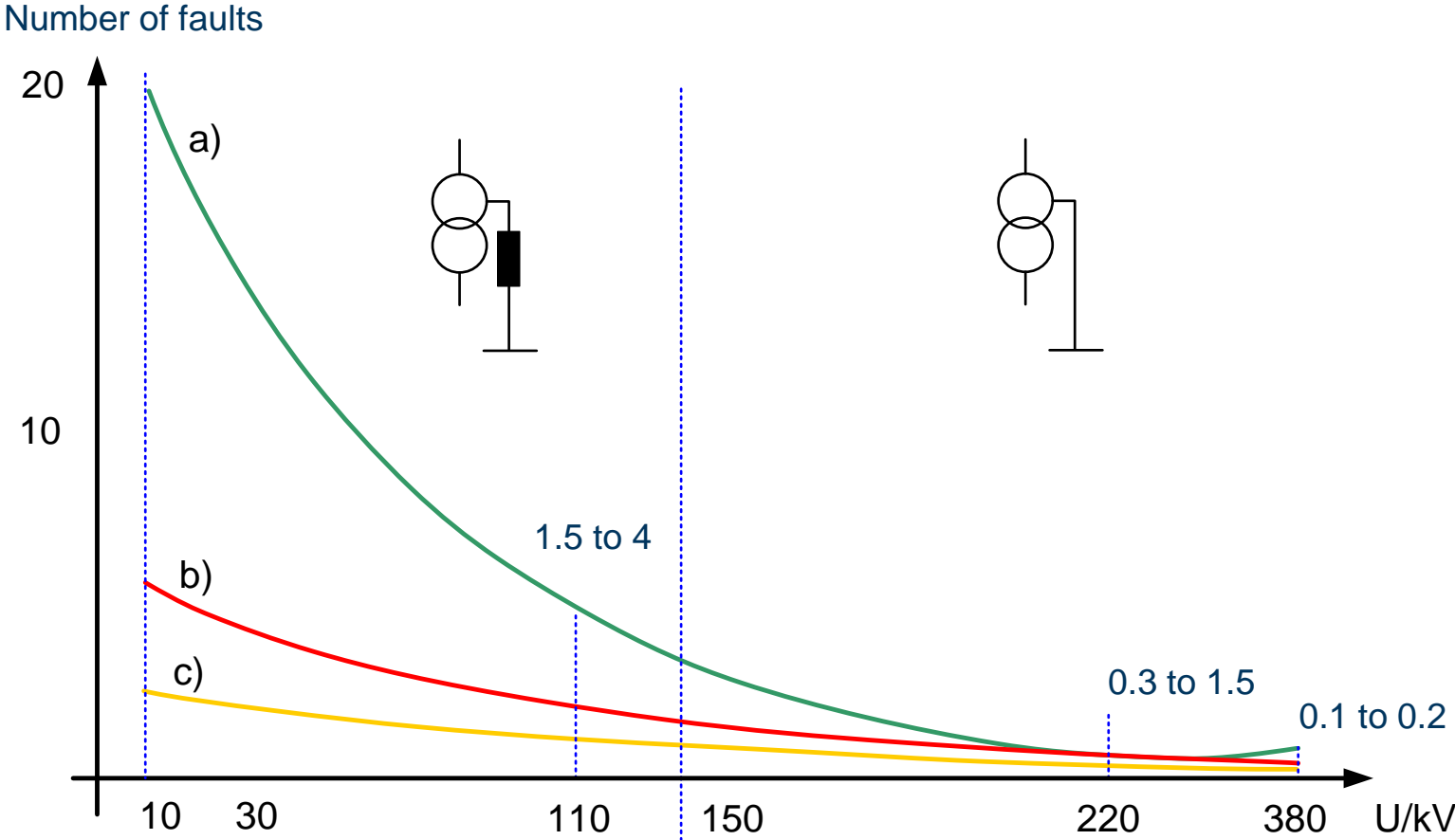
a) Single-phase   b) Phase to phase   c) Three-phase

Goals of the distribution system operators

1. Reduce downtime

▸ Fault location narrowing, targeted activation/switching

▸ Rapid restoration

▸ Save costs, optimize revenues

2. Monitoring – transparency on the grid – knowing what's going on

- Assessing the grid situation + calculating + simulating it

- Simple station messages + i-ONS status

- Predictive Maintenance

- Grid automation in the medium + low voltage grid

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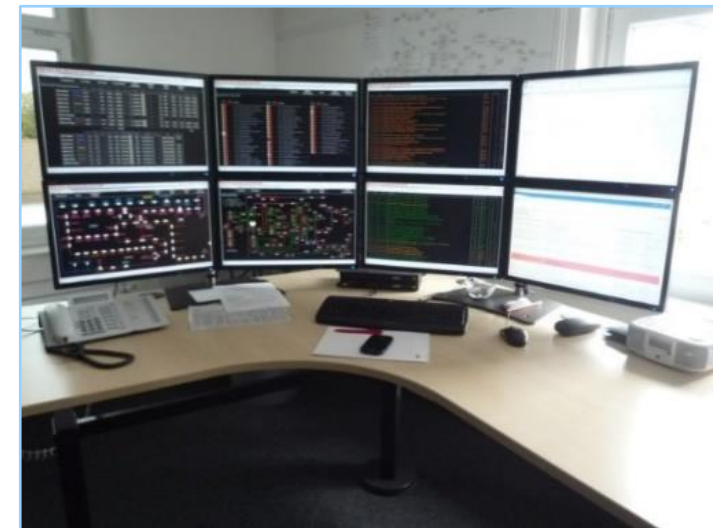
Overview of topics – Ways to digitize the distribution grid

- Detecting network faults

- Transparency in the distribution grid

- Secure data transfer

- Measured values, conditions and central evaluation

- Carry out measures

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Modern local network stations

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Focus – Medium Voltage Switchgear
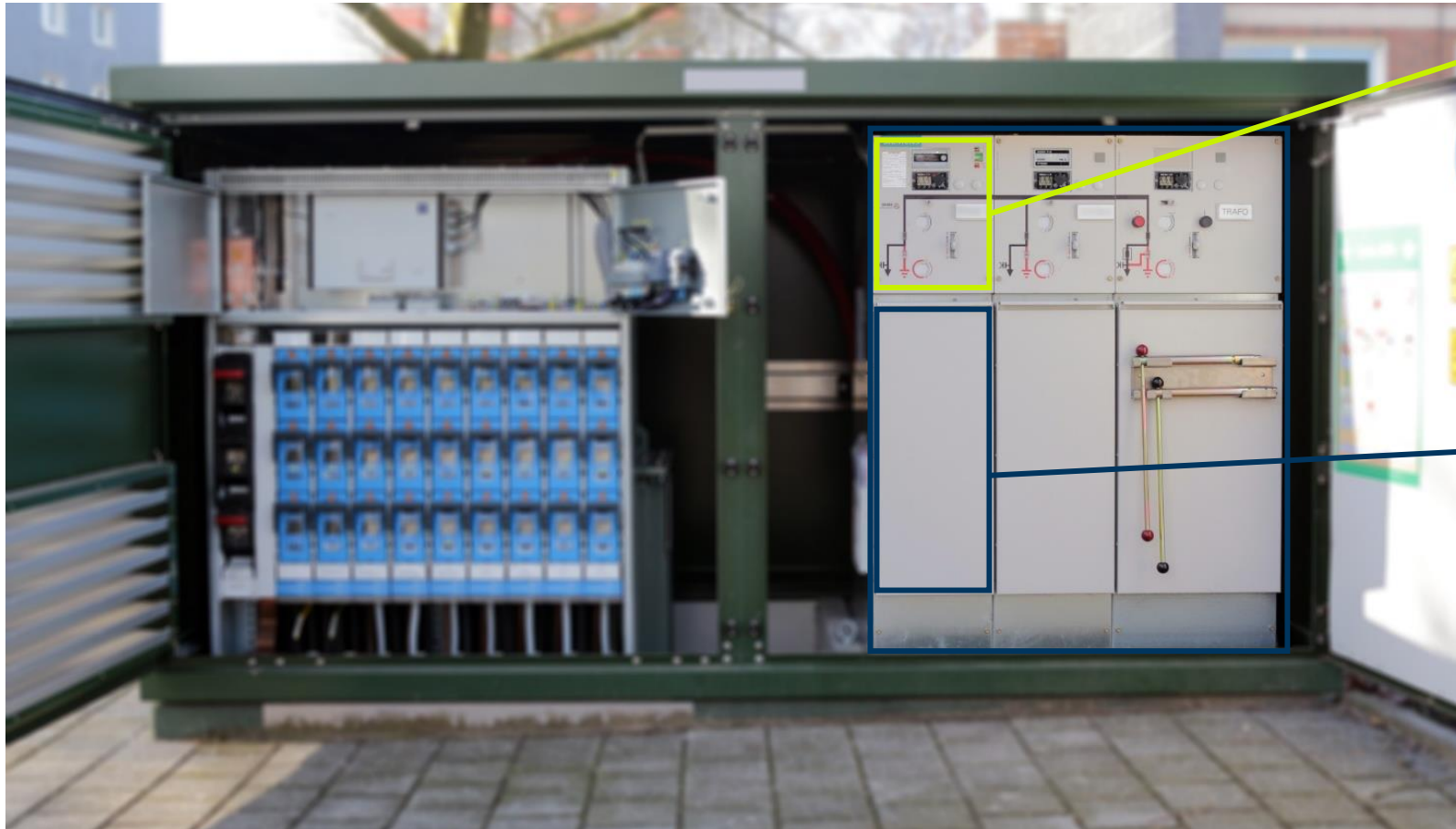
Focus – Medium Voltage Switchgearer

Power Signals
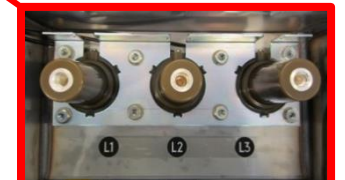
Voltage signals

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Principle of fault detection – Open ring

Typical 10 – 20 kV

Short-circuit indicator (addressed)

Fault location located

Circuit breakers

Substation/Feed

Transformer station

Separation point open

Circuit breakers
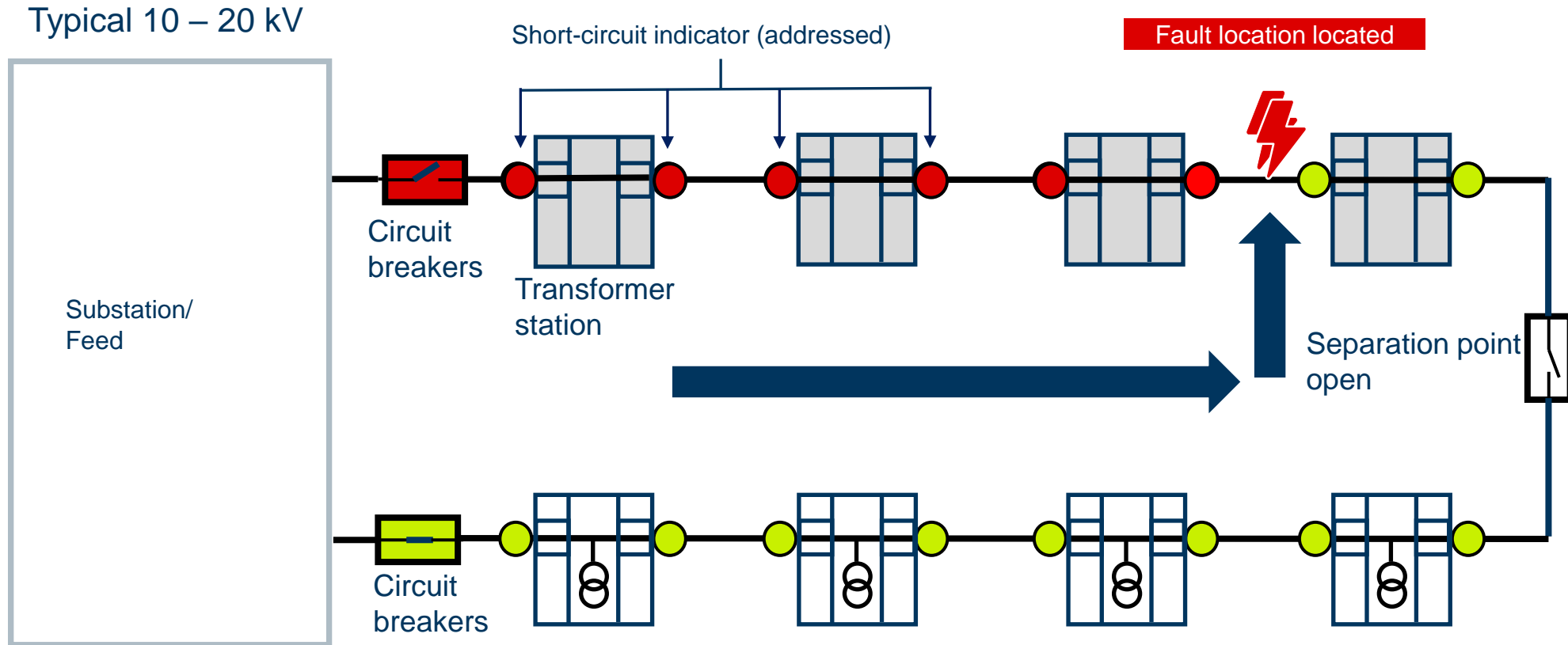
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Principle of fault detection – decentralised feed-in

Fault direction indicator stimulated in the direction of A

Fault direction indicator stimulated in the direction of B

Circuit breaker

Substation/Feed

Trafostation

Circuit breaker

Residual current towards the plant field

Residual current in the direction of cable outlet

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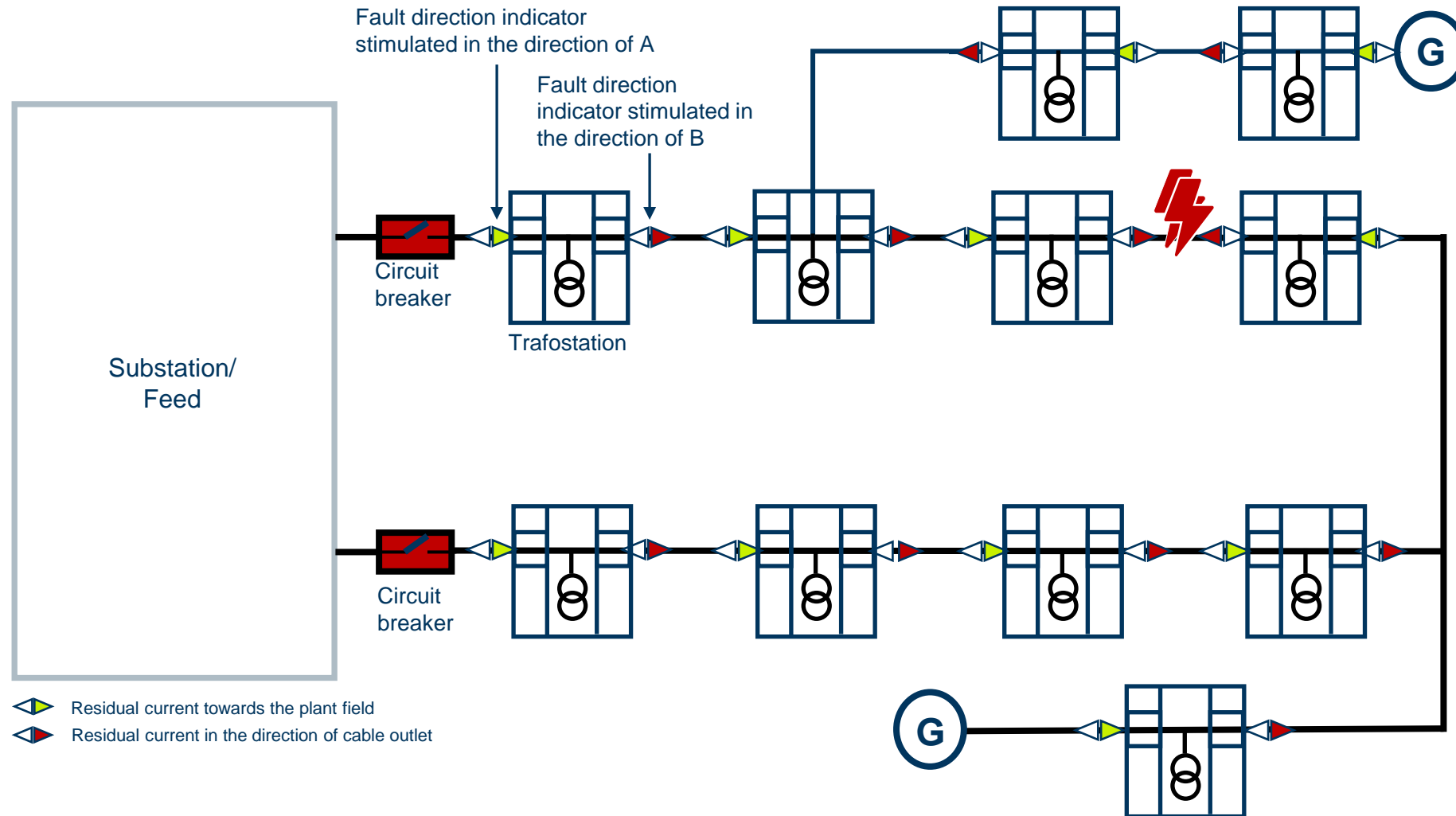
Challenges posed by change

Past

Today

Load flow unidirectional

HV
MV
LV

HV
MV
LV
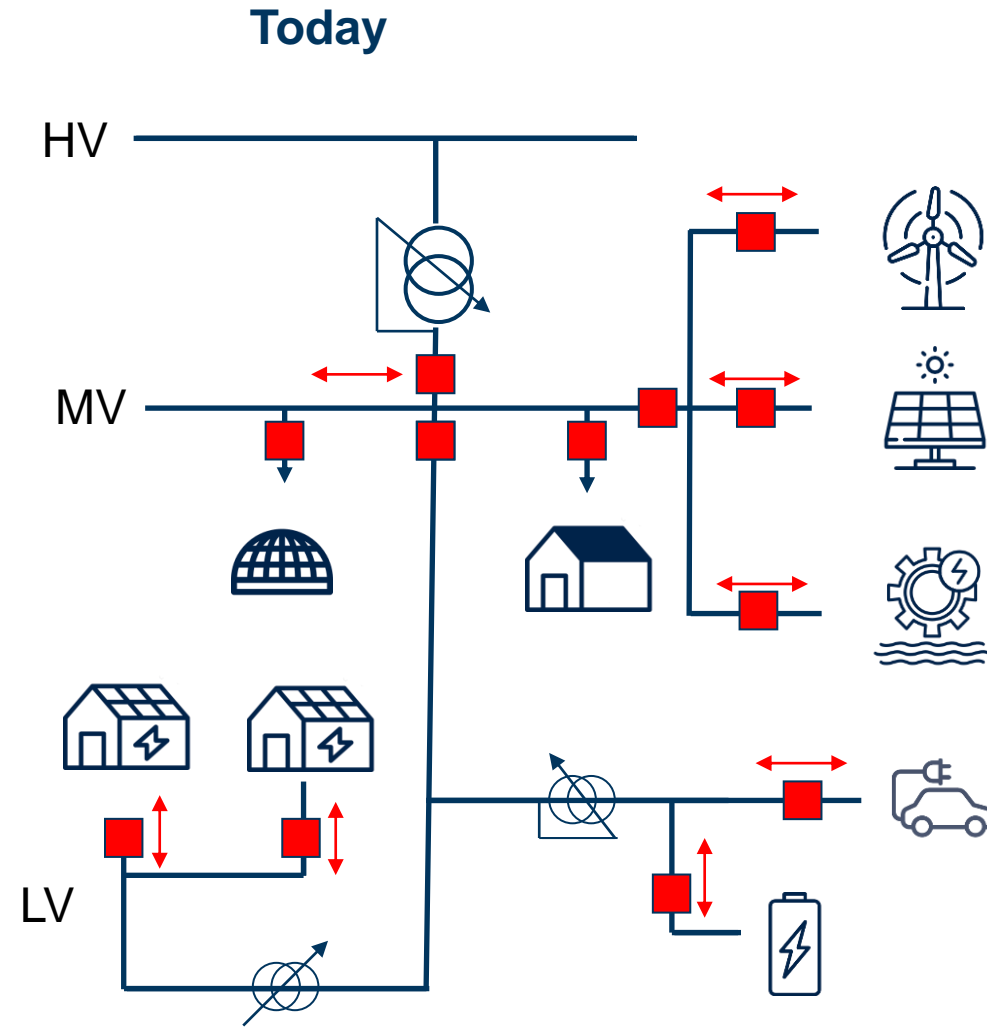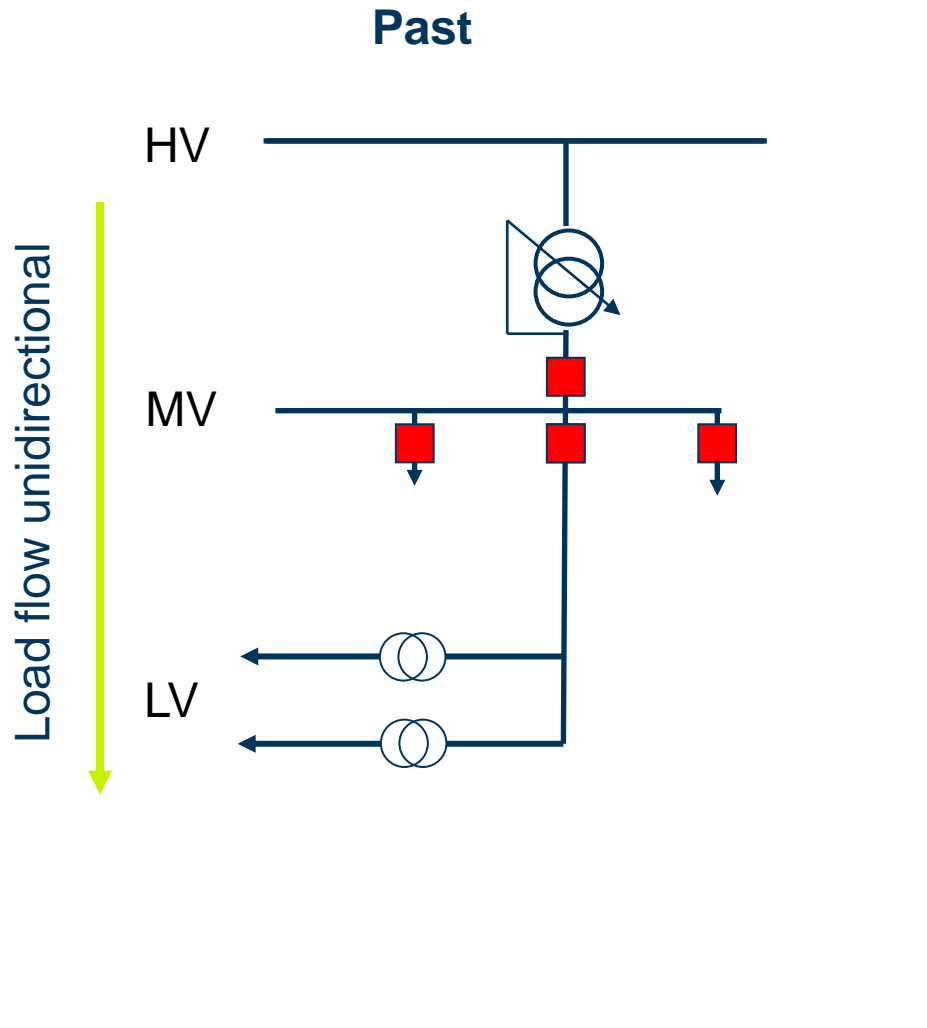
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Optimized process with Horstmann products

grid disruption
Info in control room

Normal operation restored

Fault location localized

Repair and recovery

Cutting mains supply Remote / Manual

Switch on Remote / Manual

Travel time
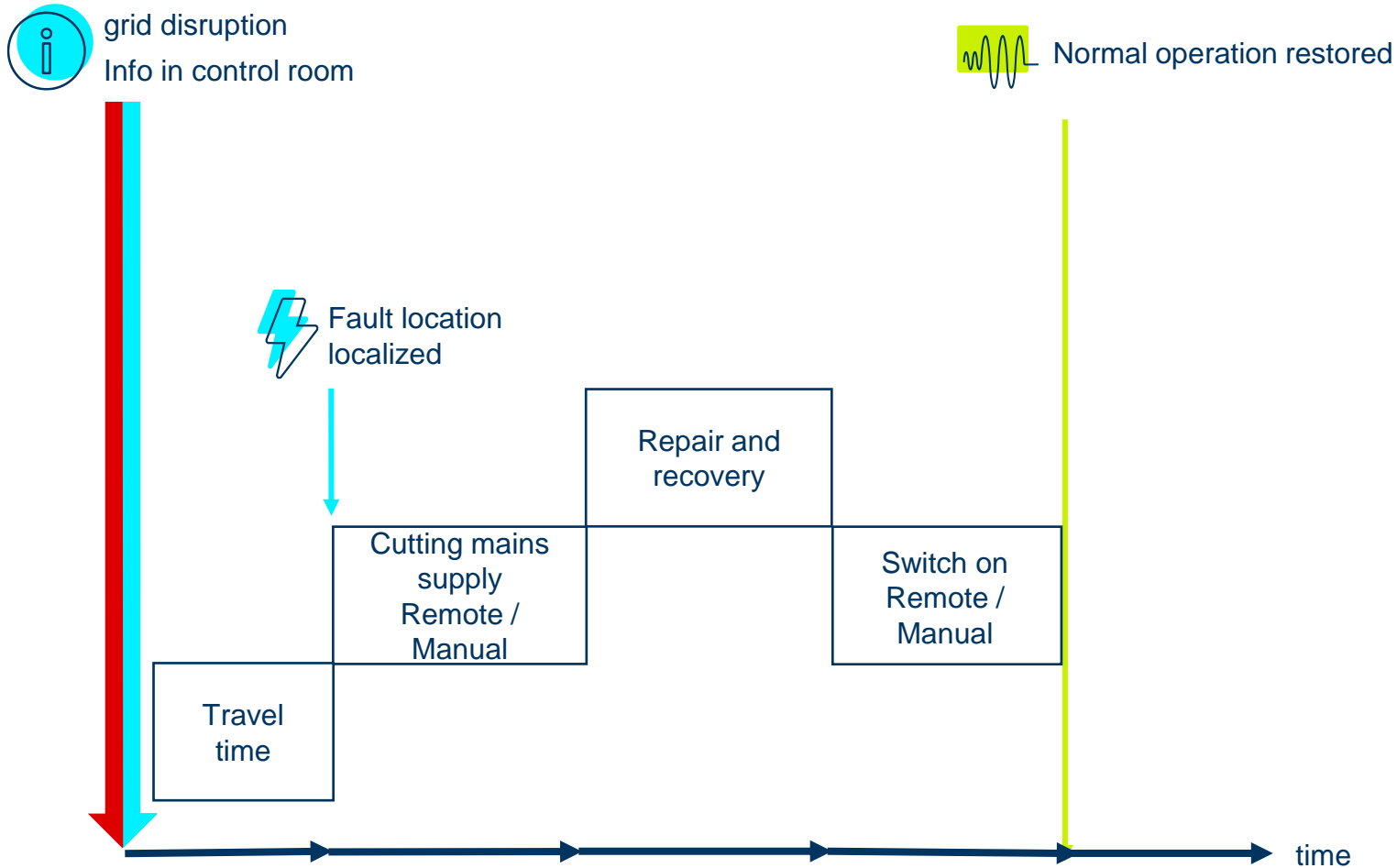
time

50 – 80%
Reduced downtime

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Products through the ages

1946
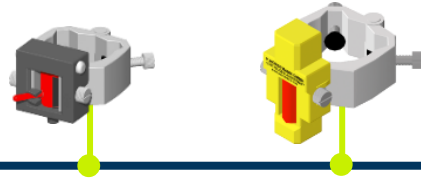
Error display

Electronic short-circuit indicators
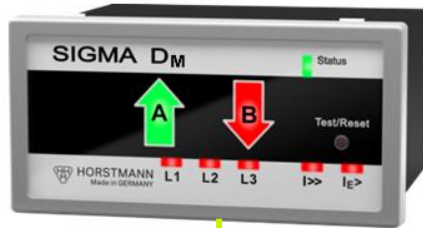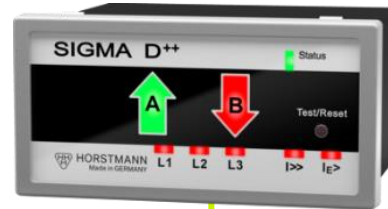
Easy monitoring | Fault Direction Indicator | New sensor technology

High-precision Monitoring | Switching Functionality | Modern Protocol

2024

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Digitization of the distribution grid – some influencing factors

The future of the distribution grids depends, among other things, on:

▸ Regulatory framework

▸ IT / Network Infrastructure + Cybersecurity

▸ Financial resources and the motivation to bring new technologies into the distribution grid

▸ Skilled workers and qualification of operating personnel

▸ People who want to make a difference

Gemeinsam das Energienetz der Zukunft gestalten
PASSION FOR PERFECTION

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Short and earth fault indicators for cable networks

Product groups
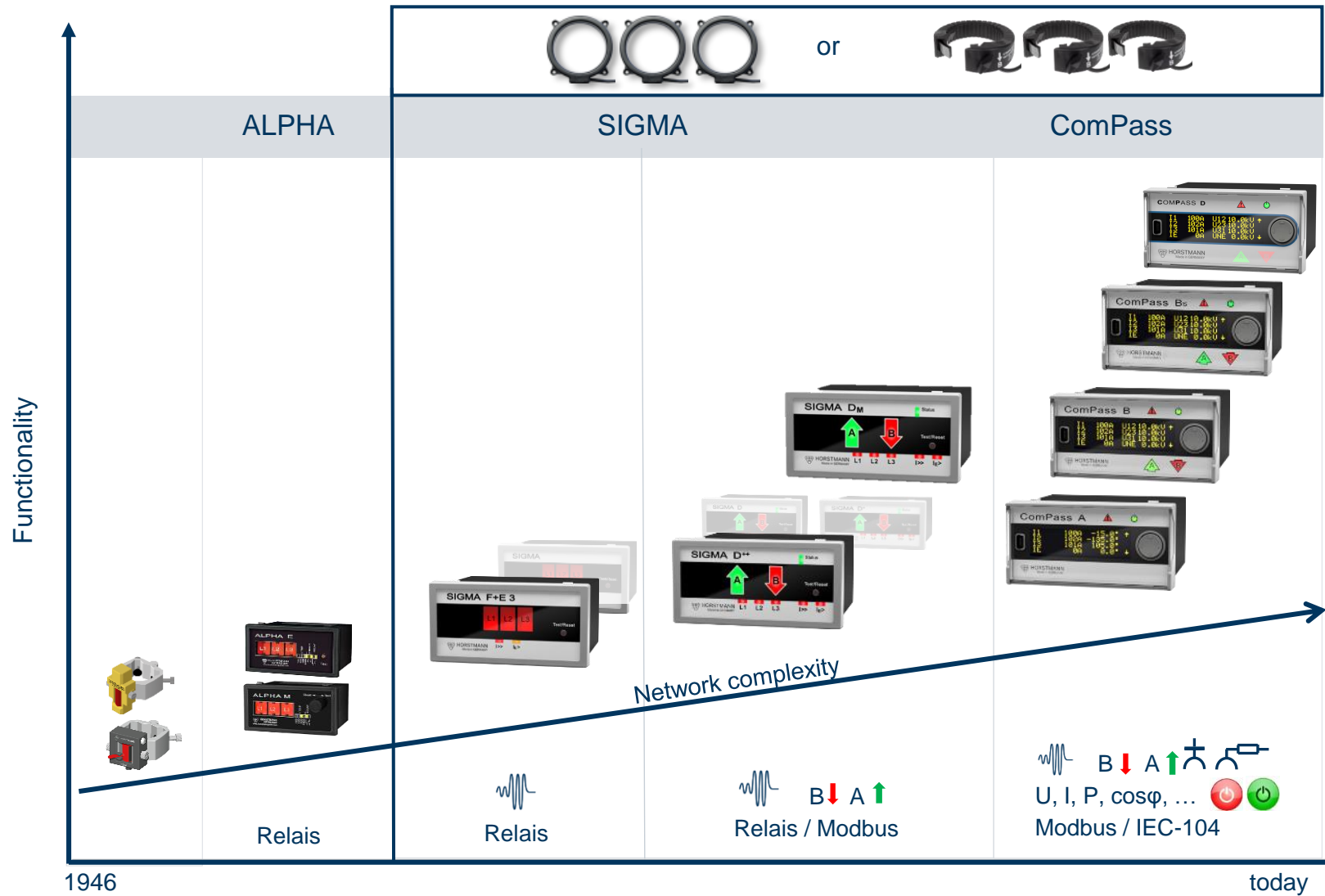
ComPass B 2.0

Short and earth fault indicators

ComPass B 1.0: Current and Voltage Sensors

Standard application in gas/air/solid-insulated plants 12 kV/24 kV/36 kV

ComPass B function:

▸ Measurement data acquisition and transmission

▸ Directional short and ground fault indication

Current Measurement Data Acquisition with Sensors
Accuracy: Class1, 300 A ext 200%

▸ sensitive, for earth fault detection

Voltage data acquisition via VDIS WEGA

▸ VDIS (voltage testing according to IEC 62271-213)

▸ ±3-5%, AutoKal = Easy calibration in the field

▸ ±1 %, ExpertKal = Special calibration in the field

ComPass B 2.0 – neue Funktionen

- Clear fault direction indication and on-site measuremrnt: 2 directional arrow LEDs without display activation

- 5 earth fault detection methods (combinable)

- Two-stage transient earth fault detection

- Monitoring:
  - Voltage (U, I, P, Q, S, PT100), (limit monitoring)
  - Load flow direction
  - Power factor (cos φ)
  - Energy
  - Frequency
  - User-friendly operating software via USB
  - All mesh types/star point treatments

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Switching ComPass Bs 2.0 – further functions

- Remote control of switch disconnectors and circuit breakers

- 4 Output Relays

- Condition Assessment 6 am. Inputs

- Setting Double Commands/Double Feedbacks

- Report Switch Positions Disconnector + Grounding

- Monitoring the shifting process
  - Time Overflow Switch Feedback
  - Load and reactive current fraction
  - Freely programmable PLC logic of the switching conditions

- Remote engine control fault

RS485

Ring-/
Kabelfeld

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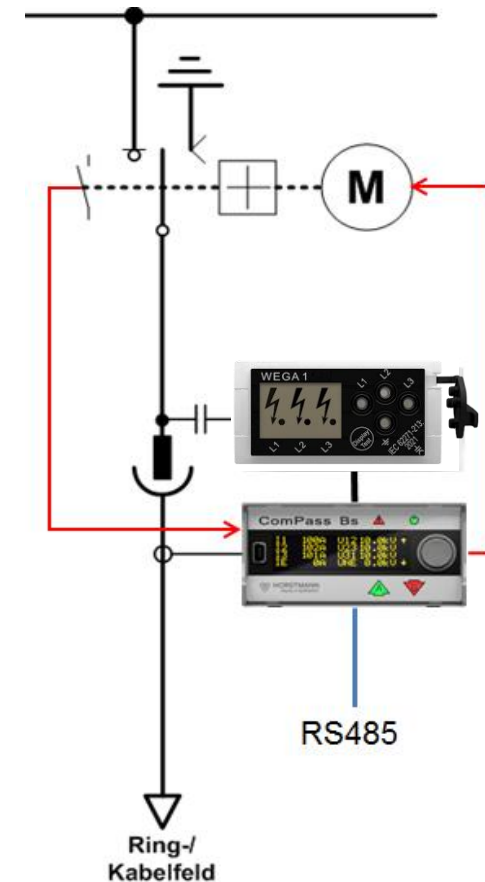
Field-related voltage measurement via Wega and automatic voltage calibration with resistive sensors
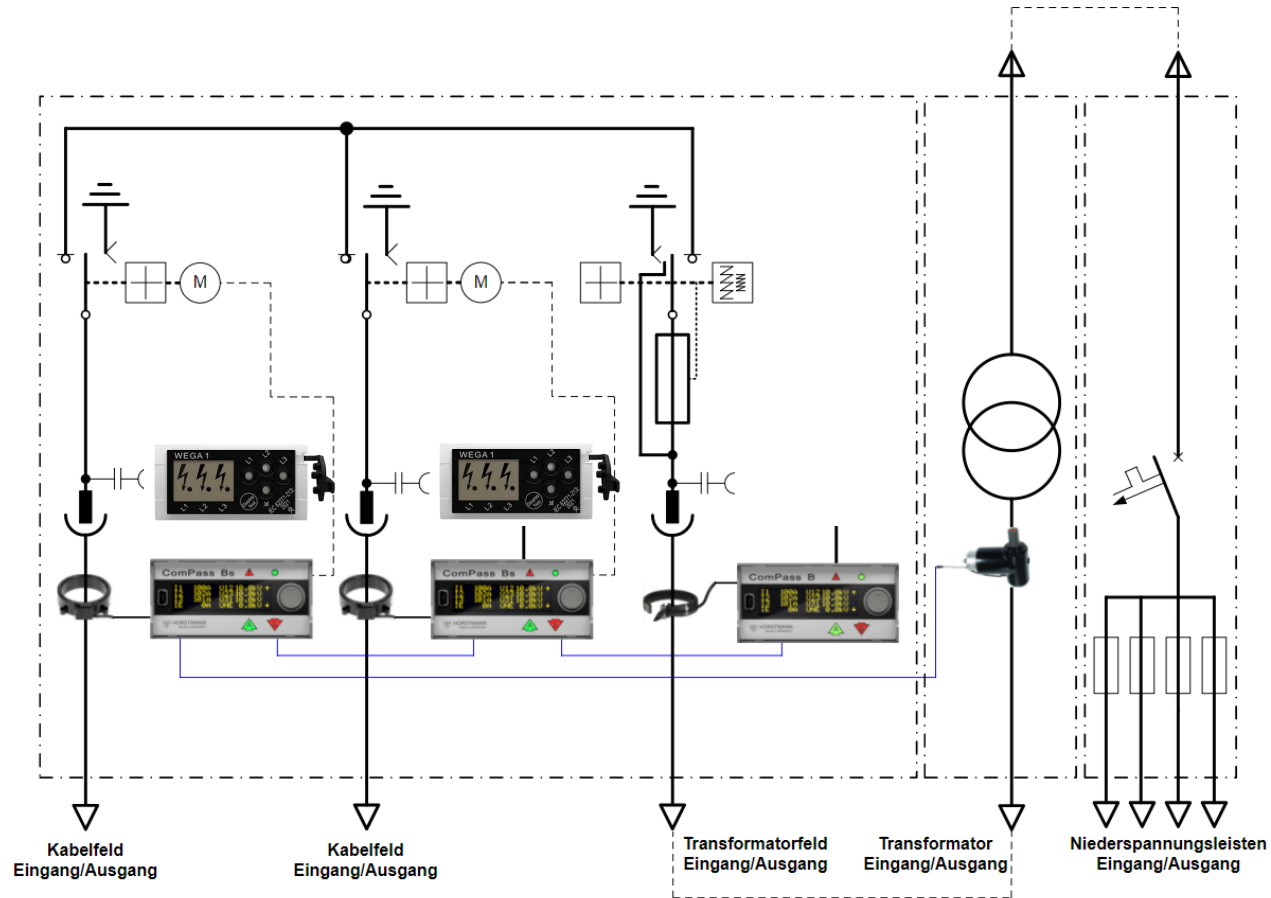
The high-precision voltage sensor is positioned on the transformer

COM**P**ASS **D** – D = **D**igital communication

- ▸ **C**OM**P**ASS D
  - ▸ Basic functionality of the ComPass B series
    - ▸ Universal Short & Ground Fault Direction Indicator
    - ▸ Precise monitoring of U, I, P, Q...
    - ▸ Connection of local sensors and actuators, e.g. for switching
    - ▸ Digitization = IP communication with Ethernet port → use of multiple & parallel communication paths (IP sockets)
    - ▸ SCADA Protocol IEC 60870-5-104
    - ▸ Device management locally / remotely via Scada data configurator and ComPass Explorer
    - ▸ The following options are only in preparation as PROJECT PLANNING
      - ▸ Cloud application: Data via MQTT (e.g. in JSON format)
      - ▸ Device management with external IoT platform incl. certificate authentication, encrypted TLS communication, patching capability (FW and config update)

NEW

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Lecture Recap: System architecture /Remote communication

▸ IEC Standards / Protocols:

  ▸ IEC 60870-5 → Telecontrol tasks

    ▸ IEC 60870-5-1   Transmission frame formats

    ▸ IEC 60870-5-2   Transmission procedures

    ▸ IEC 60870-5-3   Structure of the application data

    ▸ IEC 60870-5-4   Definition and coding of information elements

    ▸ IEC 60870-5-5   Basic application functions

    ▸ IEC 60870-5-101   Application-related standard for telecontrol tasks (serial com.)

    ▸ **IEC 60870-5-104**   **Application-related standard for telecontrol tasks in IP networks**

▸ IEC 60870-6 → Control center coupling

  ▸ Telecontrol Application Service Element 2 (**TASE.2**)

     or also known as Inter-control Center Communications Protocol (**ICCP**)

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Lecture Recap: SCADA

- SCADA = Supervisory Control and Data Acquisition
- **Basic processing**
  - Connection between process coupling (remote terminal unit), process image and command input
  - Calling the information processing programs (applications)

  - Maintaining the data model and central process image (states of the attributes of the objects)
  - Processing of information between telecontrol computer and command input
  - Storing the events and values in the archive

  - Regular renewal of input data approx. every 10-20 sec.

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Lecture

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COMPASS D - Digital communication for distribution grid automation

▸ Application example: Communication with IEC 60870-5-104

Central network control technology

Measured data
Control function,
FDI-Message
IEC60870-5-104

ScadaDataConfigurator

ComPass Explorer

Firmware- and configuration update

USB

Local Service Interface

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COMPASS D - Digital communication for distribution grid automation

▸ Application example: Communication with IEC 60870-5-104

Operations management medium-voltage grid
▸ Measured data
▸ Control function
▸ FDI-Message
▸ IEC60870-5-104

▸ ScadaDataConfigurator
▸ ComPass Explorer

Control center

USB Interface

COMPASS D - Digital communication for distribution grid automation

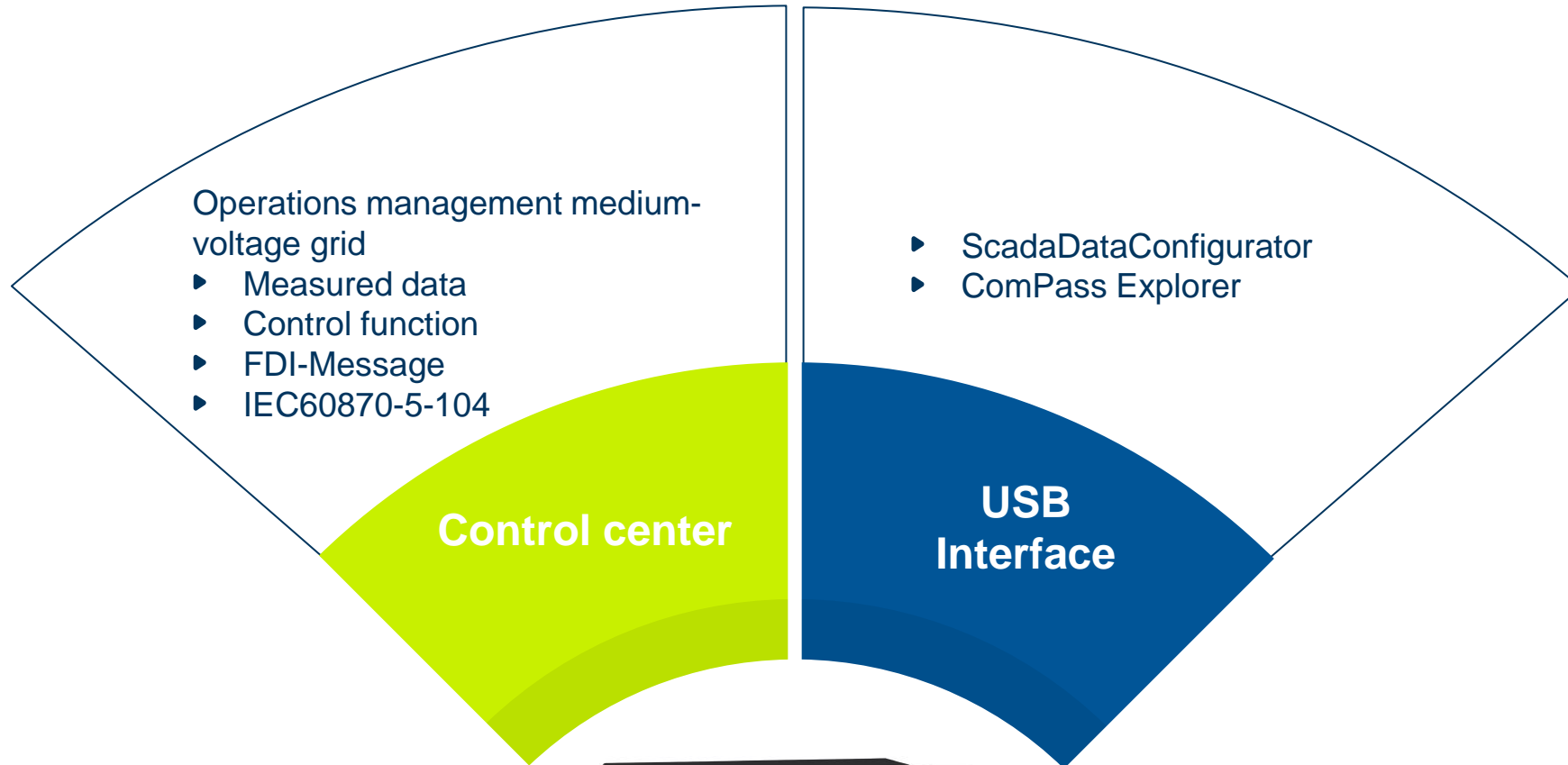▸ Application Example: Remote Configuration with Scada Data Configurator via TCP/IP

ScadaDataConfigurator

Firmware- and configuration update

SCADA Data Konfigurator
Datei   Erweitert   Service   Hilfe
○ USB   IP Adresse: 192 . 168 . 65 . 235 55555   Verbinden
● TCP/IP

Tabelleninformation | IEC Tabellenkonfiguration | MQTT Tabellenkonfiguration

Gerätename   ComPass 2.0 ETH
Version   0.001
Konfigurationdatum

Central network control technology

Measured data
Control function,
FDI-Message
IEC60870-5-104

ScadaDataConfigurator

Firmware- and configuration update

ComPass Explorer

SCADA Data Konfigurator
Datei   Erweitert   Service   Hilfe
                         . 65 . 235 55555   Verbinden

ComPass 2.0 Explorer
Datei   Kommunikation   Parameter   M
onfiguration | MQTT Tabellenkonfiguration

Projektierung | System | Sensoren | Kurzschlus ETH

Netzparameter
    Leiter-Leiter Spannung
    Nennfrequenz

Sensoren
    Stromsensoren

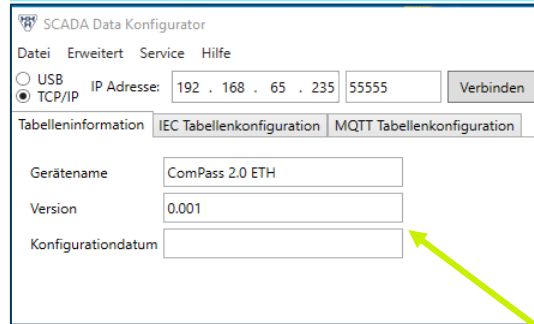Local Service Interface

USB

COMPASS D

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COM**P**ASS D - Digital communication for distribution grid automation

▸ Application Example: Remote Configuration with Scada Data Configurator via TCP/IP

Operations management medium-voltage grid
- ▸ Measured data
- ▸ Control function
- ▸ FDI-Message
- ▸ IEC60870-5-104

Central network control technology

- ▸ ScadaDataConfigurator
- ▸ ComPass Explorer

USB Interface

ScadaData Configurator
- ▸ FW-update
- ▸ config-update

https Interface

COMPASS D - Digital communication for distribution grid automation

▸ Application Example: Remote Configuration with Scada Data Configurator via TCP/IP

ScadaDataConfigurator

Firmware- and configuration update
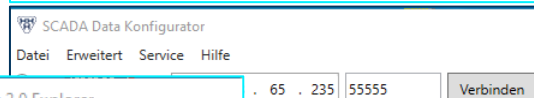
Type identifier: x112

Central grid control technology

Projecting

Measured data
Control function,
FDI-Message
IEC60870-5-104

grid planning,
grid load factor
Evaluation

Cloud

Provision of (all) data
MQTT in JSON format

ScadaDataConfigurator

Firmware- and configuration update

ComPass Explorer

Local Service Interface

USB

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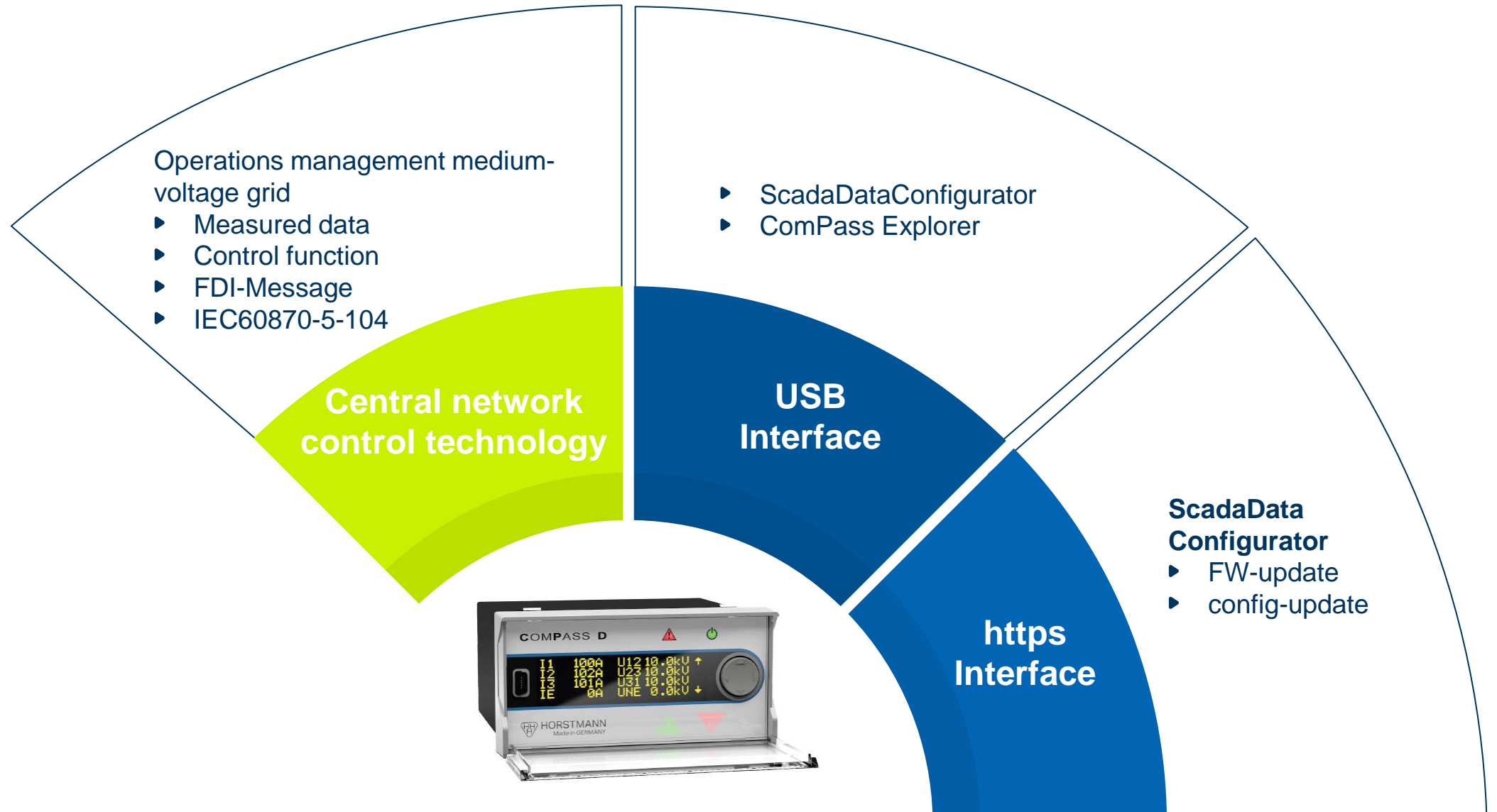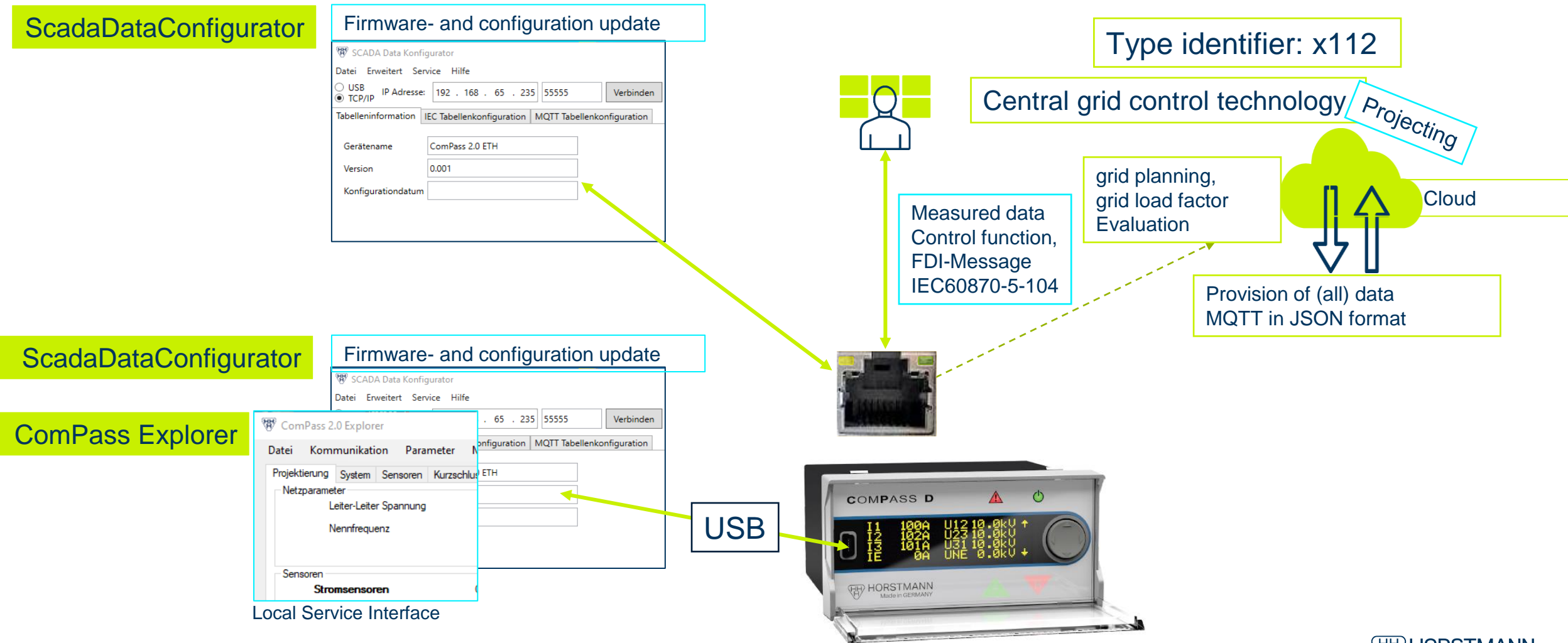
COMPASS D - Digital communication for distribution grid automation

▶ Application Example: Remote Configuration with Scada Data Configurator via TCP/IP   Type identifier: x112

Operations management medium-voltage grid
- ▶ Measured data
- ▶ Control function
- ▶ FDI-message
- ▶ IEC60870-5-104

Central network control technology

▶ ScadaDataConfigurator
▶ ComPass Explorer

USB Interface

Projecting

Cloud
- ▶ Data collector
- ▶ Evaluation
- ▶ Data about MQTT

https Interface

Equipment monitoring via IoT platform
- ▶ Inventory
- ▶ Commissioning
- ▶ FW update
- ▶ Config update
- ▶ Maintenance

System **C**OM**P**ASS D

Type identifier: x111

Operations management medium-voltage grid

Data Collector, Evaluation

Equipment monitoring
About IoT Platform

Projecting

Inventory
Commissioning
FW-update,
Config update
Maintenance

https:

Measured data
Control function,
FDI-Message
IEC60870-5-104

https:

Projecting

Provision of
(all) Data MQTT

ScadaDataConfigurator

Firmware- and configuration update
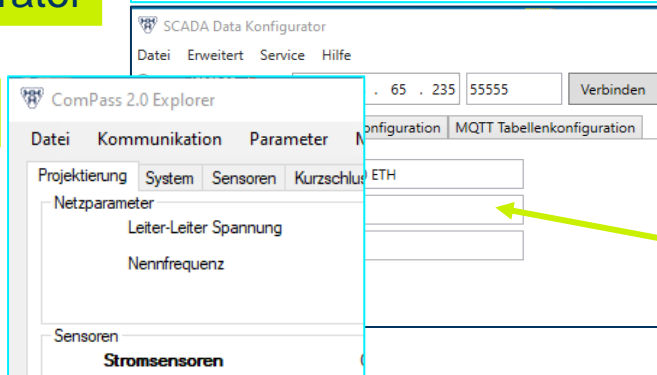
Measured values, control function,
fault display

ComPass Explorer

USB

COMPASS D

Local Service Interface

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COM**P**ASS D - Digital communication for distribution grid automation

Type identifier: **x111**

Operations management medium-voltage grid
▸ Measured data
▸ Control function
▸ KA-Meldung
▸ IEC60870-5-104

▸ ScadaDataConfigurator
▸ ComPass Explorer

Central network control technology

USB Interface

Projecting

Cloud
▸ Data collector
▸ Evaluation
▸ Data about MQTT

▸ Measured data
▸ Control function
▸ Error display

Substation

https Interface

Projecting

Equipment monitoring via IoT platform
▸ Inventory
▸ Commissioning
▸ FW update
▸ Config update
▸ Maintenance

Voltage Sensors for ComPass

Voltage Sensors

Resistive Voltage Sensors

Capacitive Voltage Sensors

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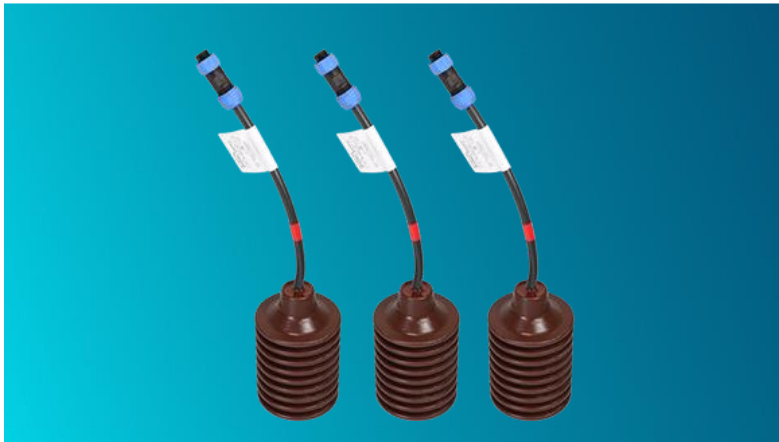
current sensors

Short-circuit current sensors for new installations on bushings

Ground fault current sensor – divisible

Application examples | CSOR

Short-circuit indicator

For overhead lines

Digitization in the overhead line network

- Fault detection algorithms
- Fault direction indicator
- Load flow monitoring

- Conductor Temperature Sensor
- Remote message directly from the conductor
- End-to-end encrypted communication

Navigator Options

Navigator-LM	Smart Navigator 2.0
≤46 kV	

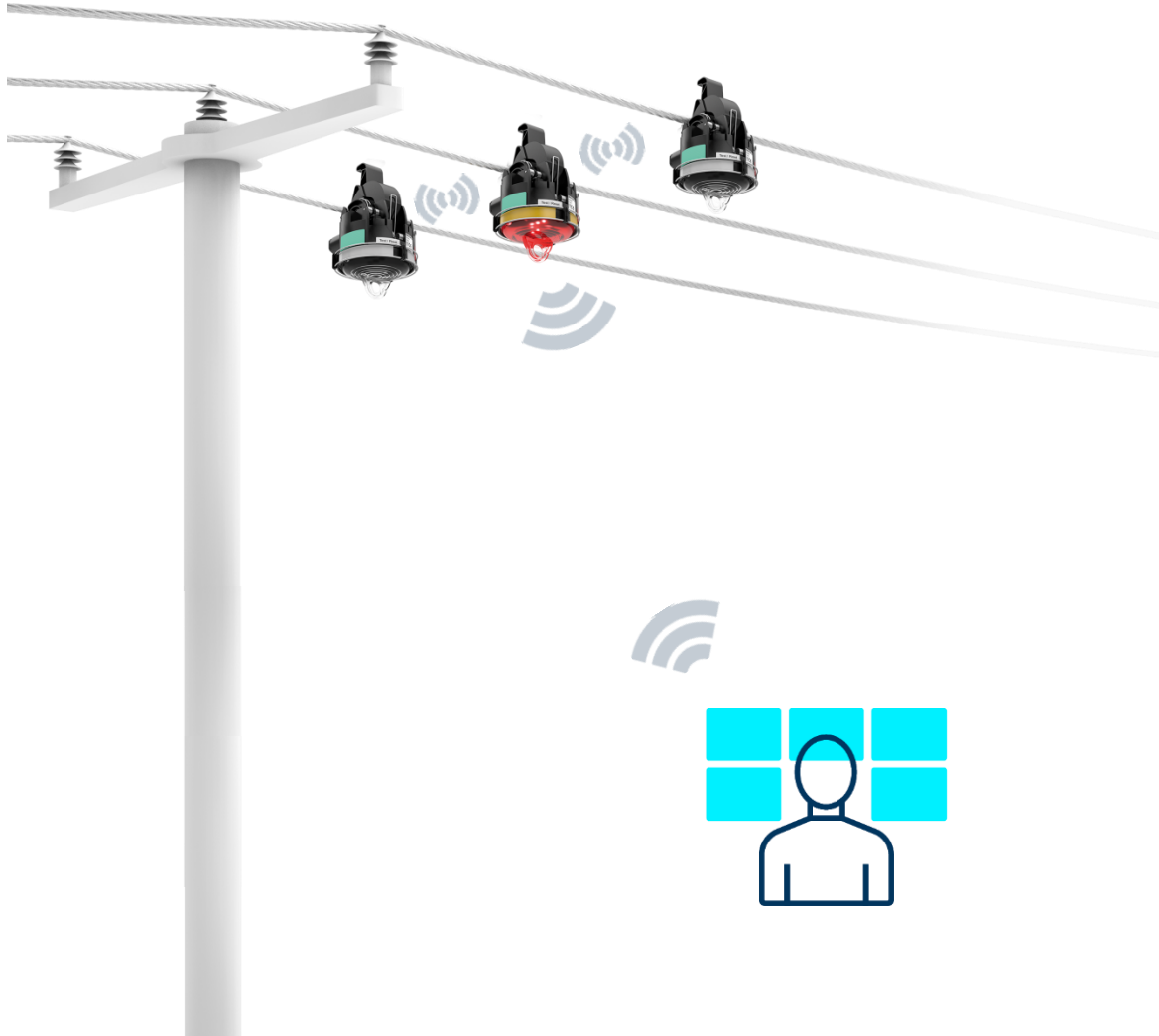| Navigator-LM HV	Smart Navigator 2.0 HV
≤161 kV	

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SMART NAVIGATOR 2.0

Smart Navigator 2.0

▸ Intelligent Fault Detection

▸ Overhead line monitoring

▸ Energy Harvesting

▸ innovative assembly

▸ Remote maintenance

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Smart Navigator 2.0 Features

Innovative Sensors

▶ Phase Current Sensor

▶ E-Field Sensor

▶ Conductor Temperature Sensor

▶ Ambient temperature

Fault detection

▶ Residual current detection: I>> (standard)

▶ Current superelevation: ΔI / Δt (Optional)

▶ Voltage drop: U < 20% Un

▶ Current flow interruption: Load current < 3A

▶ Innovative trip characteristics for special applications
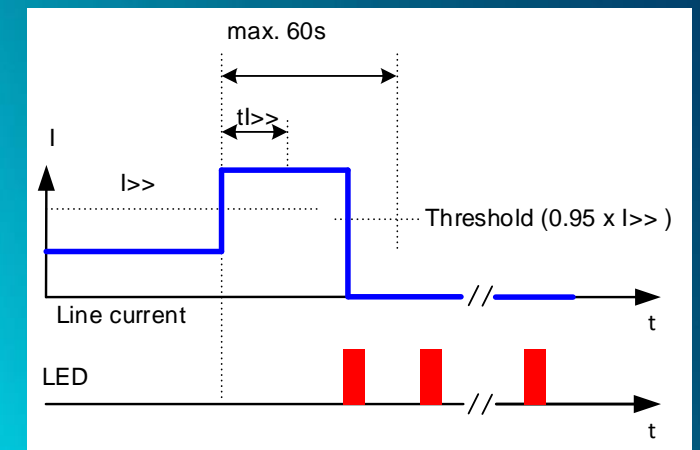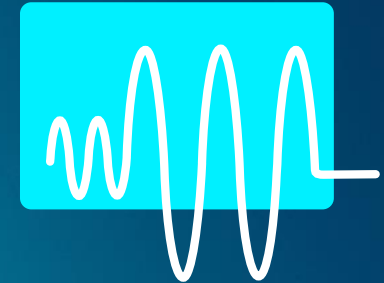
Smart Navigator 2.0 Features

Visual display

▸ Residual current indicator: RED or GREEN

▸ Indicator after power return: YELLOW

▸ Visibility (ultra-bright LEDs): approx. 100 meters

Remote notification

▸ Direct event remote message

▸ Monitoring of all measured values with time stamp
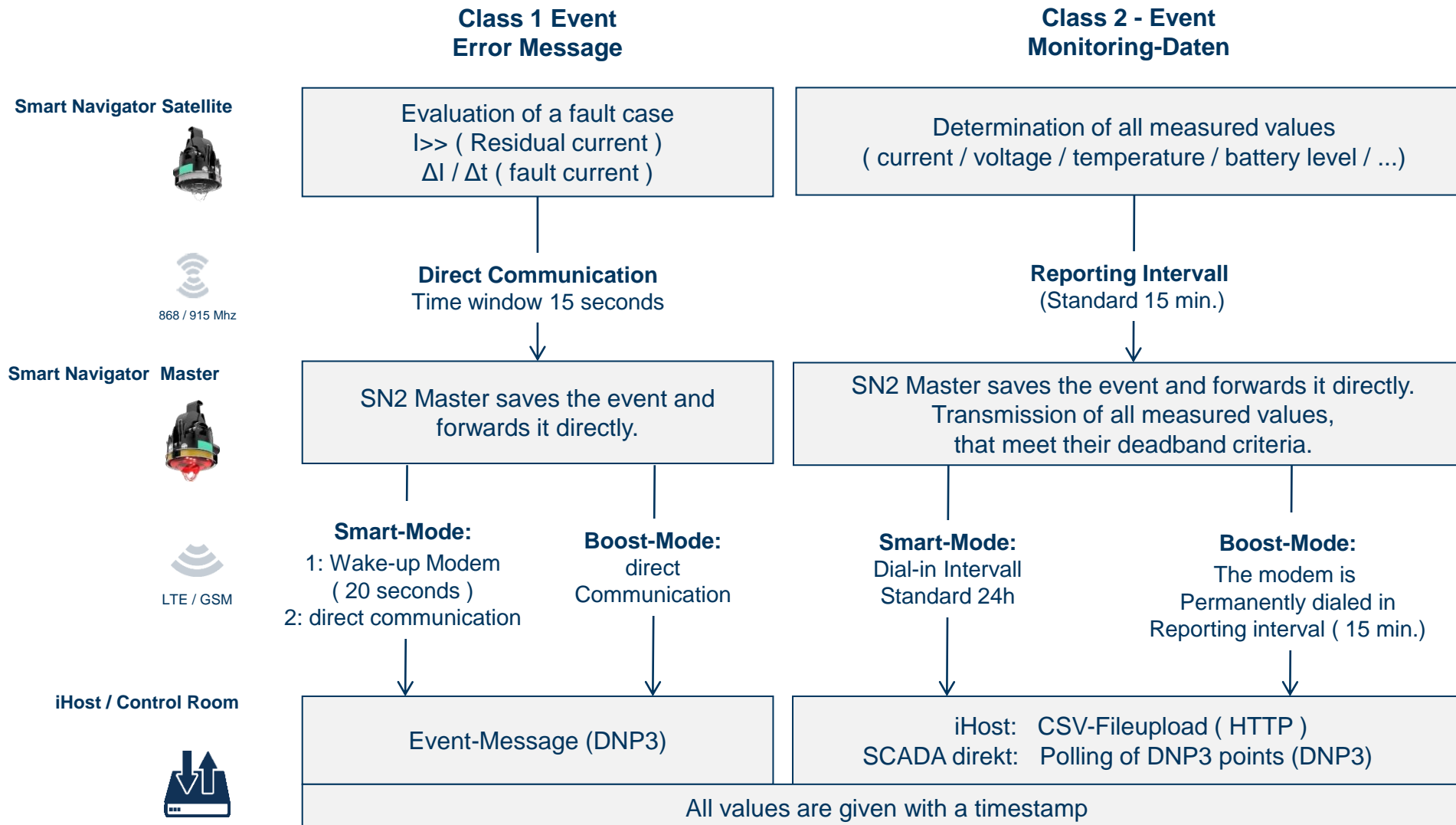
Smart Navigator 2.0 Features

Energy Harvesting

- ▶ Self-powered by the load current (>5 A)
- ▶ rechargeable battery (buffer time >72h)

More secure wireless connection

- ▶ Master <=> satellite (range up to 50 m)
- ▶ Mobile communications (LTE / GSM) for telecommunications
- ▶ private APN / public APN
- ▶ TLS 1.2 encryption

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Measurement and communication process

Smart Navigator Satellite

868 / 915 Mhz

Smart Navigator Master

LTE / GSM

iHost / Control Room

	Class 1 Event **Error Message**	**Class 2 - Event** **Monitoring-Daten**

Evaluation of a fault case I>> (Residual current) ΔI / Δt (fault current)	Determination of all measured values (current / voltage / temperature / battery level / ...)

Direct Communication
Time window 15 seconds

Reporting Intervall
(Standard 15 min.)

SN2 Master saves the event and forwards it directly.	SN2 Master saves the event and forwards it directly. Transmission of all measured values, that meet their deadband criteria.

Smart-Mode:
1: Wake-up Modem
(20 seconds)
2: direct communication

Boost-Mode:
direct
Communication

Smart-Mode:
Dial-in Intervall
Standard 24h

Boost-Mode:
The modem is
Permanently dialed in
Reporting interval (15 min.)

Event-Message (DNP3)	iHost: CSV-Fileupload (HTTP) SCADA direkt: Polling of DNP3 points (DNP3)

All values are given with a timestamp

iHost

iHost – Smart Fault Indicator Headend

- Data concentrator, protocol converter, configuration management.
  The right data in the right place at the right time

- Receives and stores all station data

- Analyzes / evaluates the station data and transmits it in the IEC60870-5-104 or DNP3 protocol

- Complements the control room with station and network information

- Significantly reduces network downtime due to rapid fault location narrowing

iHost - Link between field devices and control room

- With the iHost platform, you can efficiently manage the increasing number of intelligent components in the network.

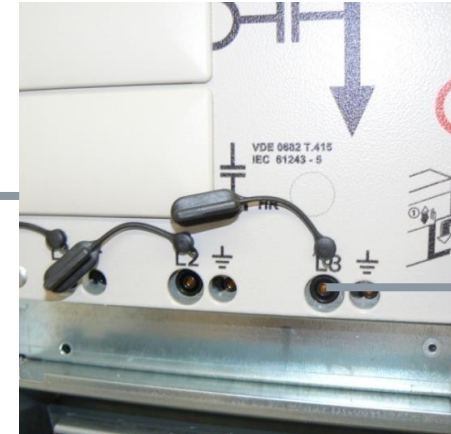- iHost supports the optimal use of the field devices and thus increases the information content in the control room.
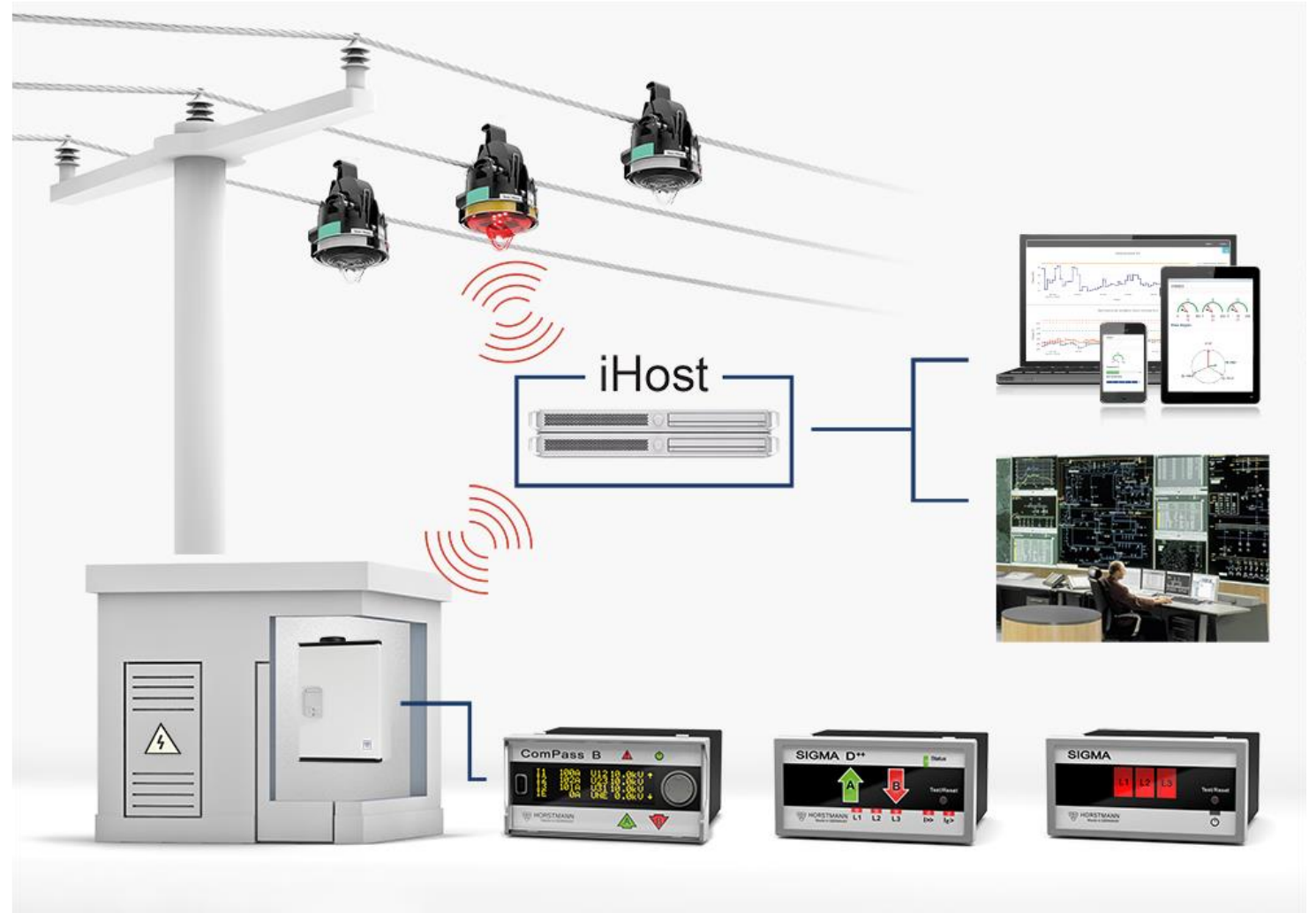
Voltage testers and phase comparators

Capacitive Voltage Test Systems (VDIS)

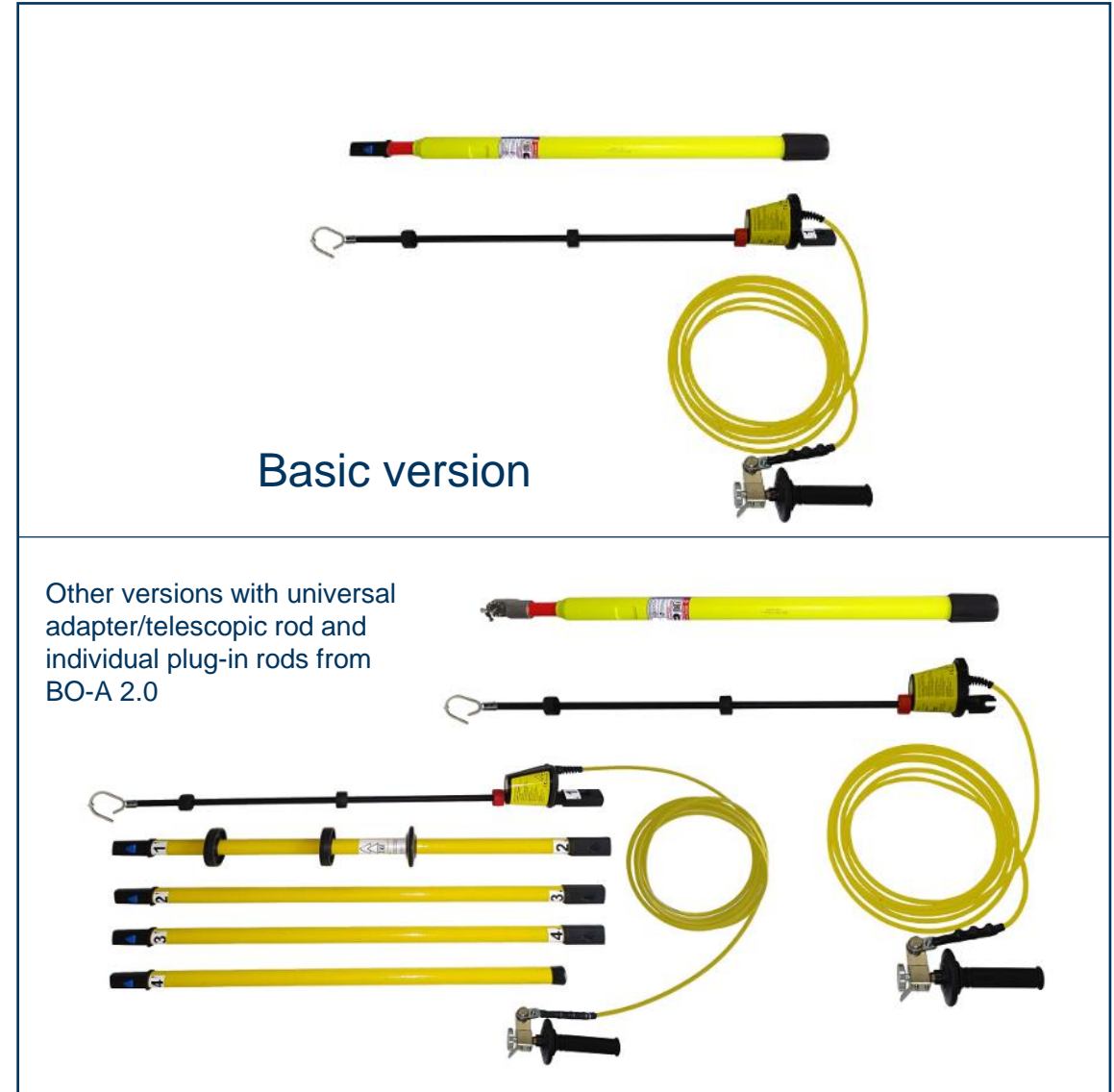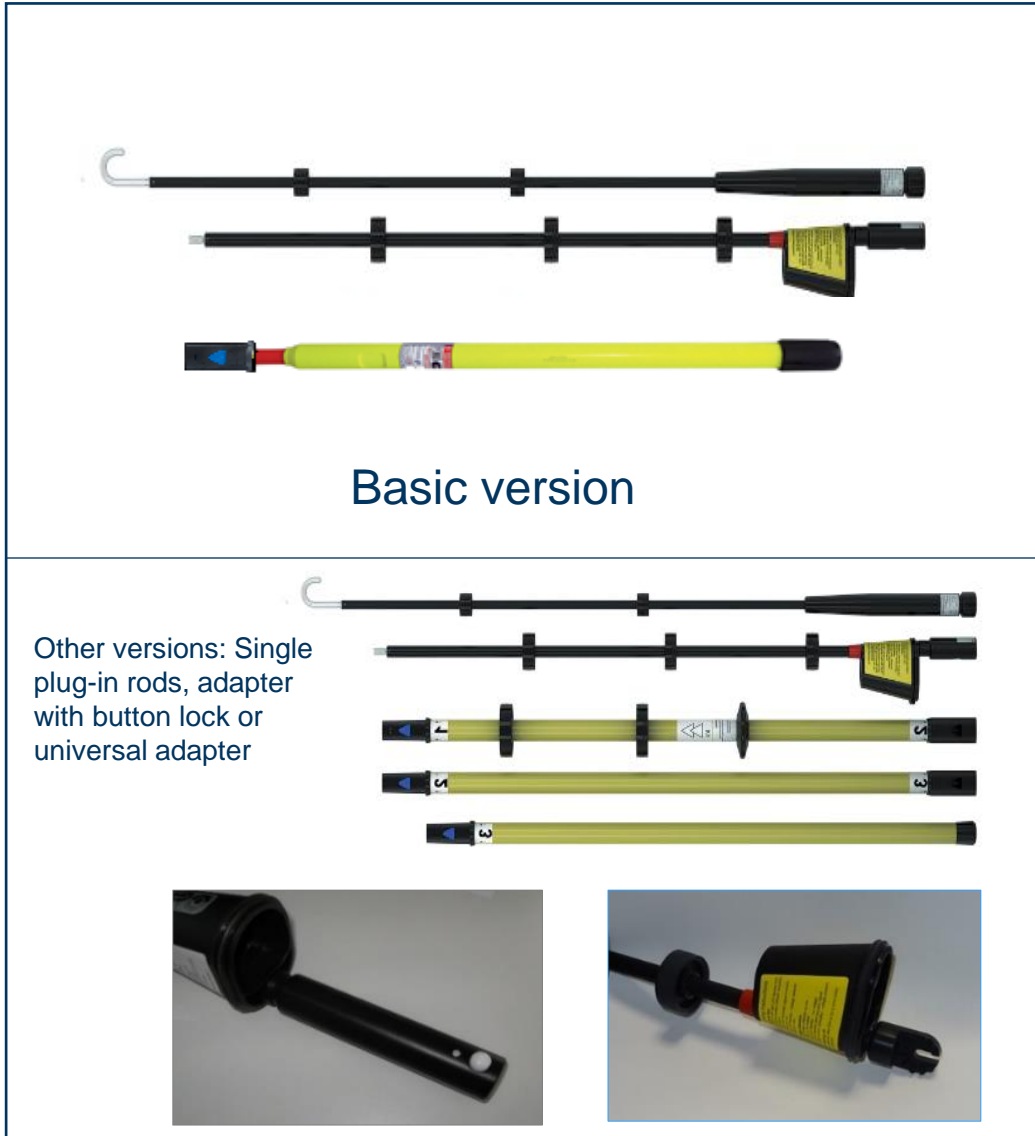Integrated VDIS: WEGA 1

Pluggable VDS: HR-ST

Main Application:

▸ Checking for zero potential of Voltage
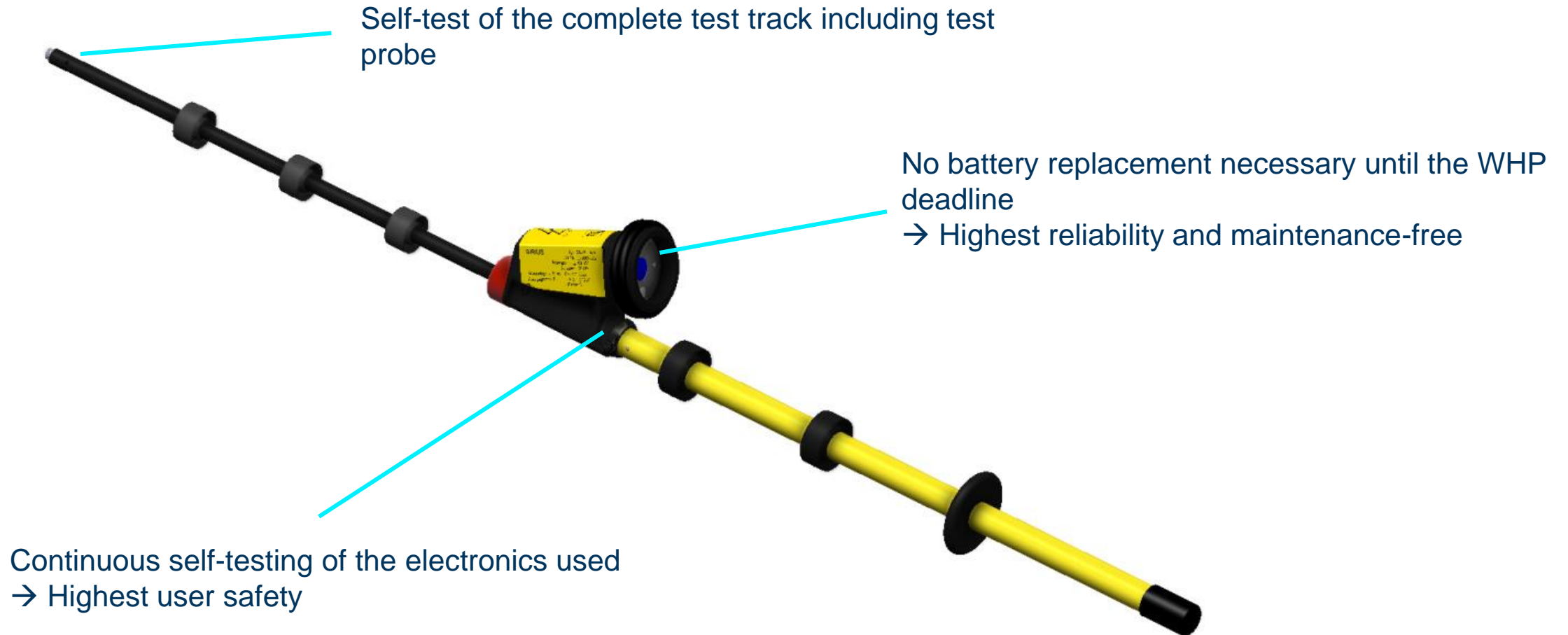
▸ Phase comparison UP
  (Universal Phase Comparator)

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BO-A AC/DC and BO-A 2.0

Overview of designs

Basic version

Basic version

Other versions: Single plug-in rods, adapter with button lock or universal adapter

Other versions with universal adapter/telescopic rod and individual plug-in rods from BO-A 2.0

Voltage tester Sirius

Sirius - Features

Self-test of the complete test track including test probe

No battery replacement necessary until the WHP deadline
→ Highest reliability and maintenance-free

Continuous self-testing of the electronics used
→ Highest user safety

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Summary

	Detecting network faults	improved error algorithms, fault direction, Sensors
	Transparency in the distribution grid	Improved sensor technology, more measuring points, more feedback, reliable measurement data
	Secure data transfer	hardware, communication media, security and encryption, standard communication structures, Network coverage? running costs?
	Information and central evaluation	Switching states, reliable measurement data, experience? Self-healing Network? Predictive Maintenance / AI ?
	Carry out measures	Remote control, motor switch and control, UPS Optimisation of fault and maintenance operations, simple commissioning, min. on-site use
	Rapid restoration	Increase or maintain the quality of care, improve SAIDI values, more technology, more maintenance?

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