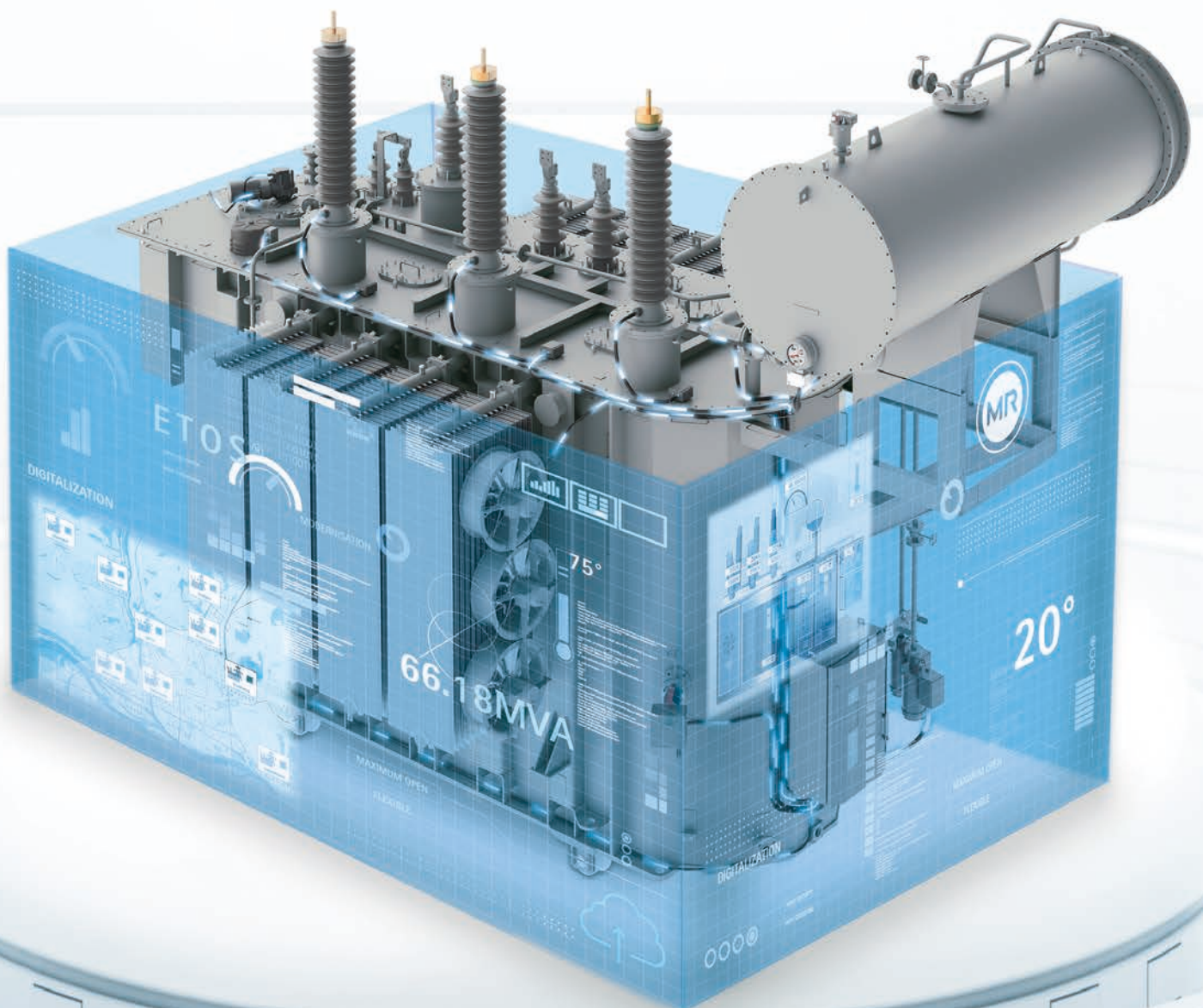# ETOS®

THE OPEN STANDARD FOR THE DIGITALIZATION OF TRANSFORMERS.

SYSTEM SOLUTION FOR AUTOMATION

ETOS®– FOR ORIGINAL EQUIPMENT MANUFACTURERS.

With ETOS® (Embedded Transformer Operating System), we for reliable monitoring, control, regulation and digitalization

There is a wide range of sensor and monitoring systems for the monitoring of power transformers on the market today. The clarification of a technical specification and the connection and integration at the transformer pose enormous challenges. In addition, topics such as the decentralization of energy production, increasing requirements for cyber security and increasing cost pressure are playing an increasingly significant role.

ETOS® provides the crucial digital interface at the transformer. To suit different customer requirements, it supports the modular integration of functions in the areas of on-load tap-changer drives, control and monitoring. ETOS® can be integrated or retrofitted seamlessly into any environment, on a single transformer or an entire fleet.

Advantages of the ETOS® system solution

❚ Control and monitoring on the transformer
❚ Central communication interface and data integrator for analog and digital signals and information
❚ Control cabinet for optimizing your value chain – without raising total costs
❚ Open for any third-party sensors
❚ Modular and functionally integrated system solution

We offer 45 years of experience with electronic systems on transformers. With our tried and tested ISM® technology, we overcome the environmental conditions on the transformer and ensure a long service life (at least 15-20 years) and reliability. Our complete range covers consultancy, choice of appropriate design and engineering of the control cabinet as well as installation and commissioning at the customer's location.

OUR SERVICES

PREPARING QUOTATIONS

❚ Meeting customer requirements through an open and state-of-the-art concept
❚ Quick and flexible price calculation and technical information
❚ All documents fast in hand

COMMISSIONING AND SERVICE

❚ Documentation and commissioning wizard directly at the device
❚ Dedicated training and services available
❚ Predictive maintenance
❚ Simple retrofitting

REDUCE COSTS AND COMPLEXITY

ENGINEERING AND DOCUMENTATION

❚ One contact partner for the entire secondary concept
❚ Open standards simplify the connection of sensors and devices
❚ Increased efficiency thanks to functional integration and innovative top drive for tap changers

LOGISTICS AND PROCUREMENT

❚ Increase of planning security thanks to our reliable logistics service

INSTALLATION AND TESTING

❚ Increased efficiency thanks to downscaled, user-oriented interfaces
❚ Benefit from automatic calibration and commissioning wizards

FOR OPERATORS AND
SYSTEM MANUFACTURERS.

provide an open system solution
of power transformers.

The growing number and greater average age of power transformers, and increasingly more demanding technical requirements on monitoring, control and regulation, are presenting growing challenges for the work of asset managers and grid management. In order to efficiently operate and maintain existing systems and prevent critical errors on power transformers, the right equipment must be at hand.

We offer modular system solutions for different applications power rating classes and models of power transformers. Decades of experience in the fields of control and monitoring of power transformers included. Through ETOS®, we are providing a complete open system for automating power transformers for the first time. It comprises monitoring and protective devices, (intelligent) sensors, field devices for control, regulation and monitoring, superordinate

fleet monitoring, and all attachment accessories for communication.

The special feature is the simple connection of components in ETOS®. This enables an individualized configuration. Likewise, a simple expansion or renewal of your existing power transformers is possible. In this way, you are able to control and monitor your transformers effectively – for maximum availability and security.

The combination of functions in a sophisticated system solution as well as the possibility of state-of-the-art connection using fiber-optic cable results in considerable savings.

OUR SERVICES

ON-SITE ASSESSMENT

❚ Inspecting the facilities
❚ Review and clarification of data sources, interfaces and communication channels
❚ Perform measurements on site

FURTHER SUPPORT

❚ Assisting in equipment evaluation and decision-making
❚ Periodically checking system integration and databases
❚ Analysis of the recorded data/equipment and measures derived from it

IMPROVEMENT
OF NETWORK
AND ASSET
MANAGEMENT
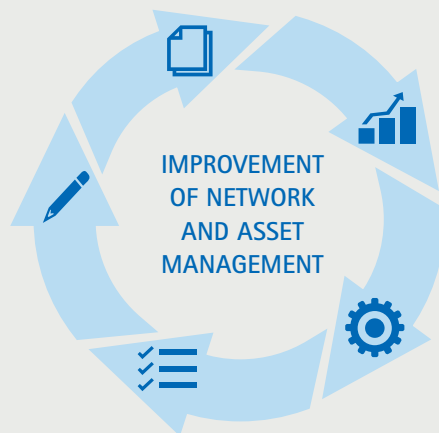
CONSULTING

❚ Developing detailed strategies for the entire system
❚ Defining project phases
❚ Providing clear and well-founded action recommendations
❚ Creating (communication) security concepts

IMPLEMENTATION

❚ Procuring/incorporating sensors, monitoring systems and communication
❚ Configuring and installing TESSA®

COMMISSIONING

❚ Performing wiring, communication and system checks
❚ Providing system documentation
❚ Training of operating personnel

MAXIMUM DEPENDABILITY. MAXIMUM VERSATILITY.

NETWORK CONTROL ROOM

CONTROL LEVEL

Superordinate visualization and control of the transformer fleet
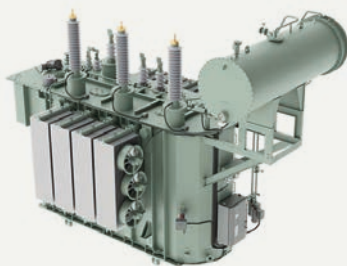
ETOS®

FIELD LEVEL

Visualization via control panels in the station building and/or directly in the control cabinet

Control, regulation and monitoring in control cabinets, mounted on the transformer
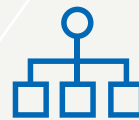
ETOS®
Standalone variant in a control cabinet

CONNECTION OF

PROCESS LEVEL

Sensors and protective devices on the transformer

IT IS POSSIBLE TO CONNECT SENSORS FROM OTHER MANUFACTURERS

MESSKO® BETECH

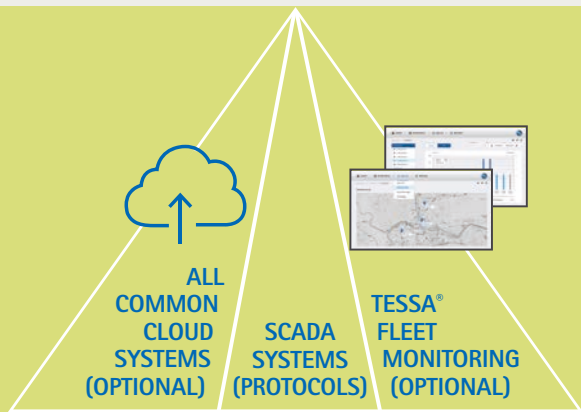MESSKO® COMPACT, MESSKO® TRASY2

Temperature monitoring

CONVENTIONAL

ALL COMMON CLOUD SYSTEMS (OPTIONAL)

SCADA SYSTEMS (PROTOCOLS)

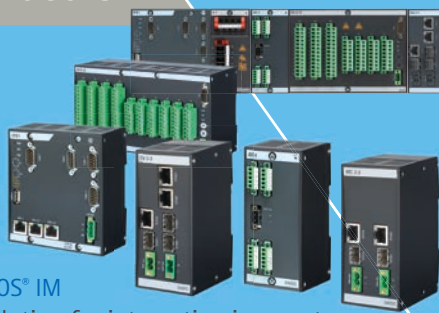**TESSA® FLEET MONITORING (OPTIONAL)**

STANDARD CONTROL-SYSTEM PROTOCOLS

ETOS® TD AND
ETOS® ED
Integration
solution in
the motor
drive

ETOS® IM
Solution for integration in a customer
control cabinet (plug-in modules)

SENSORS BY MEANS OF STANDARDIZED INTERFACES

MESSKO® MTO,
MESSKO® MMK

Level monitoring

MSENSE® VAM
Online OLTC
Monitoring

MSENSE® DGA
Online DGA monitoring

MSENSE® BM
Bushing
monitoring

MSENSE® FO
LWL Temperature
measurement

RS2001 OLTC
Protective relay

MESSKO®
MTRAB® 2.5
Maintenance-
free dehydrating
breather

MESSKO® MSAFE®
Buchholz relay

MESSKO® MPREC
Pressure relief device

MESSKO® MFLOC 2.0
Flow indicator

SENSORS

INTELLIGENT SENSORS

PROTECTIVE DEVICES / ACCESSORIES

TRUSTED COMPONENTS.
FAULT–FREE OPERATION.

Monitoring and protective devices, conventional and intelligent sensors:
With our MESSKO® and MSENSE® product brands, we offer field–tested
components at the process level that ensure decades of error–free operation.

Conventional sensors

Temperature monitoring and display

❚ MESSKO® COMPACT (Bourdon principle):
temperature measurement, measured value
display
❚ MESSKO® TRASY2 thermometer series
(Bourdon principle) specifically for temperature
measurements
❚ MESSKO® BETECH measurement system for
oil and winding thermometers with expansion
bellows technology

Level monitoring – Oil level indicator

❚ MESSKO® MTO oil level indicator
❚ MESSKO® MMK magnetic oil level indicator

Intelligent sensors

❚ MSENSE® DGA 2/3 for monitoring hydrogen,
carbon monoxide and moisture in the insulating
oil
❚ MSENSE® DGA 5/9 for monitoring hydrogen,
carbon monoxide, acetylene, ethylene, methane,
ethane and oxygen in the insulating oil.
Including methods for interpretating the gas
concentrations (in accordance with Duval, Rogers)
❚ MSENSE® BM for monitoring the condition
of the bushing insulation
❚ MSENSE® FO for measuring the winding
temperature
❚ MSENSE® VAM for vibroacoustic monitoring
of the on-load tap-changer

Protective devices / accessories for transformers and on-load tap-changers

❚ MESSKO® MTRAB® 2.5 maintenance-free
dehydrating breather
❚ MESSKO® MSAFE® Buchholz relay as a central
protective device
❚ RS2001 protective relay for protecting the
on-load tap-changer and transformer
❚ MESSKO® MPREC pressure relief device for
transformers and on-load tap-changers
❚ MESSKO® MFLOC 2.0 monitors the flow of coolant

MONITOR. CONTROL. REGULATE: ETOS®.

Monitoring

Transformer monitoring

❙ Monitoring of temperatures, powers and signals of other sensors and protective devices
❙ Limit-value assessments and calculation models to monitor the hot-spot temperature, bubbling temperature and ability to cope with overload
❙ Basic functions for all transformers included in standard package

Online DGA

❙ Monitoring of active part and winding
❙ Early detection of thermal and electrical errors for preventing failures
❙ Integration of DGA sensors per 4...20 mA or Modbus RTU
❙ Interpretation of the gas concentrations using standard analysis methods such as Duval and Rogers

Bushing monitoring

❙ Monitoring of oil-impregnated (OIP) or resin-impregnated (RIP) paper bushings for voltage levels U_m up to 765 kV
❙ Continuous recording of the state-relevant variables capacitance (C) and dissipation-factor (tan δ) directly at the bushing

OLTC Monitoring

❙ Online monitoring of temperatures, switching statistics and torques
❙ Individual calculation of maintenance intervals (particularly of oil tap changers)
❙ Efficient asset management through condition-based maintenance
❙ Vibroacoustic analysis (VAM) of the tap changer: Warnings regarding mechanical deterioration, contact problems or synchronization problems between drive and OLTC
❙ ETOS® ED: optimized real-time monitoring and analysis of the torque for the complete MR on-load tap-changer enables a longer maintenance interval

Controlling and regulating

Voltage regulation

❙ From simple voltage regulation to a wide range of parallel operation methods to complex regulation algorithms
❙ Based on 10,000 installed MR voltage regulators

Cooling system control and monitoring

❙ Monitoring of cooler starts and cooling efficiency for up to six cooling levels
❙ Intelligent and predictive control of the cooling system, taking into account the load conditions and the thermal conditions of the transformer
❙ Optionally with frequency controlled fan control. This enables effective temperature management with minimal noise and a reduced-volume cooling system

ETOS® DESIGNS

ETOS® TD
Innovative top drive
Integration solution in the motor-drive unit

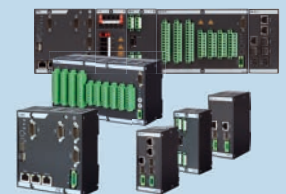**ETOS® ED**
Classic drive technology (with a mechanical linkage)

ETOS®
Standalone variant in the control cabinet

ETOS® IM
Plug-in modules
Solution for integration in a customer control cabinet

AVAILABLE PACKAGES

Transformer monitoring	Dissolved Gas Analysis (Online DGA)	Bushing monitoring	OLTC monitoring	Voltage regulation	Cooling system control and monitoring

MONITORING				CONTROL AND REGULATION	

MODULAR SYSTEM SOLUTION.
ETOS® FUNCTIONS.

Efficient control and monitoring of transformers.

ETOS® TD/ED drive function

❚ Innovative top drive or proven drive technology with
  mechanical drive linkage
❚ Integrated motor current monitoring and tap position indication
❚ Conforms to IEC 60214-1:2014

Transformer monitoring

Standard functions*
❚ Status monitoring of the protective devices (e.g. RS2001,
  Buchholz relay, PRD)
❚ Monitoring of temperatures (e.g. oil temperature and
  direct winding temperature)
❚ System voltage, load current, frequency, load factor,
  active power, reactive power, apparent power
❚ Hot-spot calculation in accordance with IEC 60076-7 or
  ANSI/IEEE C57.91
❚ Calculation of aging rate and loss-of-life
❚ Tap position capture

Advanced functions
❚ Capability of transformer to handle overload in the short
  or long term with live calculation and simulation of overload
  forecasts in accordance with IEC 60076-7 or ANSI/IEEE C57.91
❚ Calculation of the bubbling temperature
❚ Calculation of paper moisture content

Cooling system monitoring

❚ Operating status (active, inactive, error) per cooling stage
❚ Number of starts per cooling stage
❚ Operating time per cooling stage
❚ Monitoring of thermal resistance and cooling efficiency

Optional
❚ Monitoring of inlet and outlet temperature of the oil
  cooling circuit and the water cooling circuit (up to two circuits each)
❚ Calculation of the difference between inlet and outlet temperature
  of the oil cooling circuit (up to two circuits)
❚ Active monitoring by setting limit values for messages

Cooling system control

❚ Cooling stages individually parameterizable with different control
  algorithms:
  – Temperature-dependent switching point control with hysteresis
    and delay time
  – Load-dependent mode (for early activation of the cooling stages)
  – Periodic mode (for regular activation of the cooling stages)
  – Alternating mode (for uniform loading of similar cooling stages)
❚ Fail-safe mode (function monitoring)
❚ Optionally as frequency-controlled cooling system control for
  increased capacity and less wear and tear on the fans
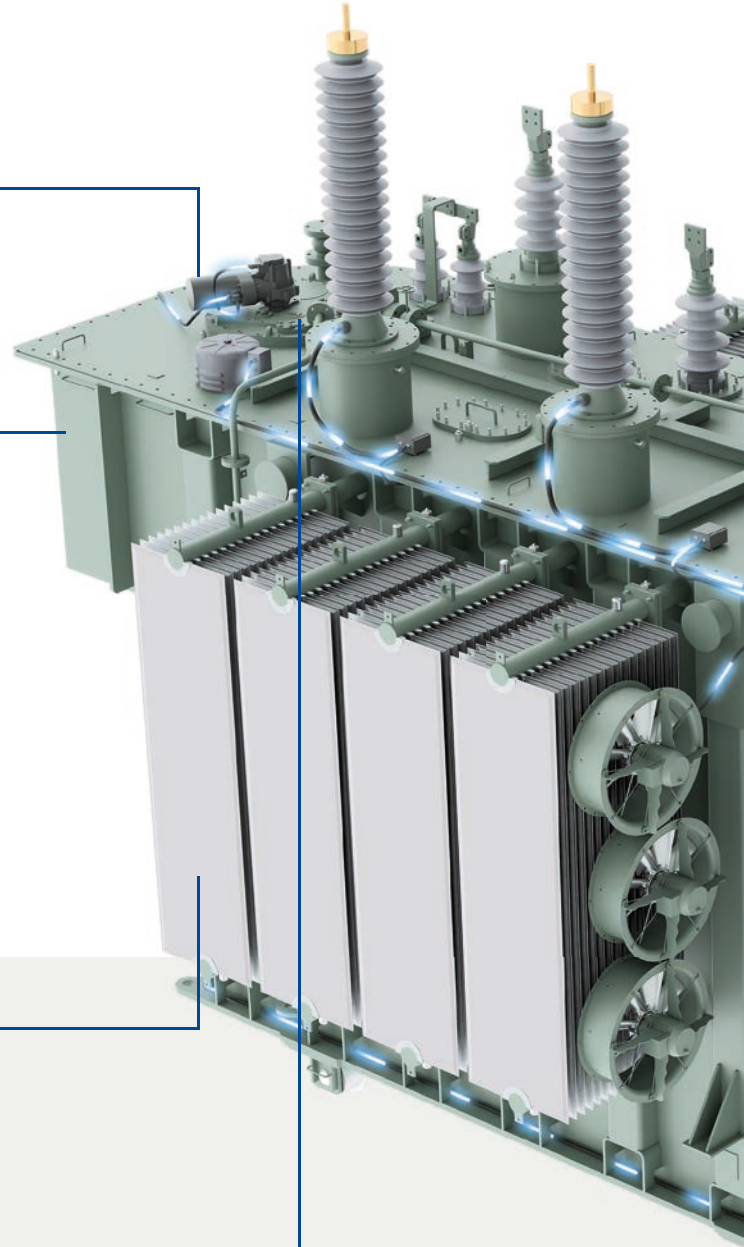
OLTC Monitoring

Standard functions
❚ Status monitoring of the motor-drive signals
❚ Maintenance recommendations and maintenance
  interval calculation for OILTAP® and VACUTAP®
❚ Calculation of contact wear for OILTAP®
❚ Tap-position statistics for the OLTC (number of
  tap-change operations/tap, duration per tap)
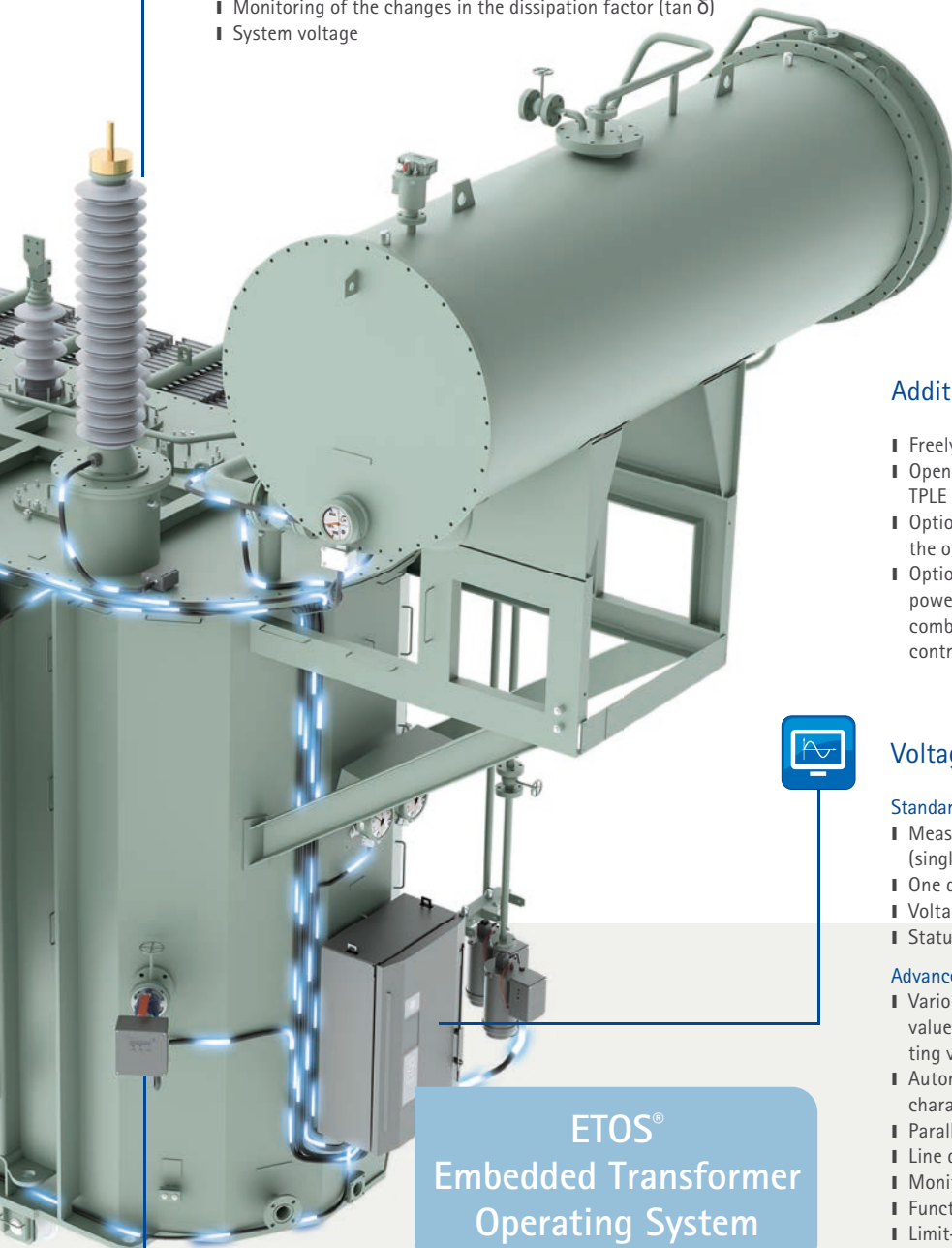❚ Monitoring of OLTC oil temperature

Advanced functions
❚ Motor Current Index in accordance with IEEE PC57.143
❚ Vibroacoustic analysis of the tap changer (VAM)
❚ ETOS® ED: OLTC torque monitoring

Bushing monitoring

❚ Monitoring of changes in C1 capacitance
❚ Monitoring of the changes in the dissipation factor (tan δ)
❚ System voltage

Additional functions

❚ Freely programmable digital and analog inputs and outputs
❚ Open programming with function blocks possible with TPLE function
❚ Optional: Integration of functions in a motor-drive for the on-load tap-changer (side drive or innovative top drive)
❚ Optional: Integration of the complete control including power unit of a conventional cooling system. Can also be combined with the advantages of intelligent cooling system control, such as predictive cooling, (on request)

ETOS®
Embedded Transformer
Operating System

Voltage Regulation

Standard functions
❚ Measurement of system voltage and load current (single- or three-phase)
❚ One desired value
❚ Voltage regulation with linear delay time T1
❚ Status of the motor-drive unit

Advanced functions
❚ Various types of desired-value setting (three or five desired values, TAPCON® Dynamic Setpoint Control, desired-value setting via analog value, raise/lower pulse, desired value via BCD)
❚ Automatic voltage regulation with linear or integral time characteristics and two delay times T1 and T2
❚ Parallel operation via CAN bus (up to 16 transformers)
❚ Line drop compensation (RX or Z compensation)
❚ Monitoring of bandwidth
❚ Function monitoring
❚ Limit-value monitoring

Online DGA monitoring

Standard functions
❚ Online recording of up to nine dissolved gases, relative moisture in oil and relative overall gas content
❚ Configurable limit value for each gas
❚ Curve display of the measured values
❚ Measured value memory
❚ Universal 4...20mA or Modbus RTU interface for capturing the DGA sensor signals

Advanced functions
❚ Standard evaluation methods in accordance with Duval, Rogers, Dörnenburg and IEC 60599

Visualization

Visualization using web server (SVG and HTML 5) included as standard for various end devices

Communication

❚ IEC61850 Ed. 1 and Ed 2. MMS, and GOOSE
❚ IEC60870-5-101, -103, -104
❚ DNP3
❚ Modbus TCP, RTU, ASCII
❚ Remote maintenance support

PERFECTLY MATCHED. HARDWARE AND SOFTWARE.

ETOS®. The system solution from a single source.

The control cabinet for your ETOS® system solution can be configured in various designs and housings as well as mounted on any transformer. Our system solution includes consultancy, configuration and choice of appropriate design as well as engineering of the control cabinet.

Fitting ETOS® directly on the transformer allows the recorded data to be transferred to the control station via network protocol using a fiber-optic cable. Compared to a conventional, copper-cable connection method, this greatly reduces the amount of wiring needed while at the same time increasing data transmission security.

ISM® modules and control cabinet

❚ Modular and efficient hardware design
❚ Specific modules for various tasks, such as measurement or communication
❚ Supports all common interface standards
❚ Permissible ambient temperature of the electronic modules during operation -25°C to +70°C
❚ Various voltage supplies with wide range power supplies
❚ Control cabinet available in various sizes and corrosion-protection classes (up to CX in accordance with ISO 12944-9)
❚ Optimized housing enables use in all climate zones
❚ Easy on site operation with integrated LED lighting, laptop holder, socket and service interface

Modular and efficient hardware design

❚ Designed for the harshest environmental conditions directly on the transformer
❚ Reliable lifespan of 15-20 years
❚ Built upon > 40 years of experience with automation at the transformer
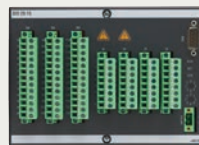
CPU
❚ 3 x RJ45 for control system communication, remote parameter setting and HMI
❚ Communication (IEC60870-5-101, -103, -104, Modbus ASCI, RTU, TCP, DNP3, IEC61850 Ed.1 and Ed2 MMS and GOOSE)

UI
Single-phase or three-phase current and voltage measurement

AIO
❚ Analog inputs (current, voltage, resistance – configurable)
❚ Analog outputs (current, voltage)

DIO
❚ Digital inputs (electrically isolated groups)
❚ Digital outputs (electrically isolated relay contacts)

MC / SW
Communication via fiber-optic cable, redundancy (RSTP, PRP)

We provide various displays (MCONTROL) for visualization. They come in various sizes and for various conditions (outdoor use, indoor use). The ETOS® visualization is matched perfectly to the user and can be operated intuitively using graphic elements. The visualization is geared for quick and smooth operation for controlling and monitoring the power transformer. Among other things, this allows data to be displayed on mobile devices. The interface for remote access is included in the standard scope of delivery.

Simple logic functions can be integrated by the operator using TPLE (= TAPCON® Personal Logic Editor) with the aid of function blocks. This enables the adaptation, optimization and ongoing development of processes at no added cost.

Software

❙ Robust operating system as the basis for all system and application functions
❙ Database of current and historical operating data as well as status and log information
❙ Web-based visualization in accordance with HTML 5 standard with SVG (Scalable Vector Graphics) with no loss of quality
❙ All necessary control system protocols, available in client or server functionality
❙ Customization with flexible digital and analog inputs and outputs, which can be programmed by the user
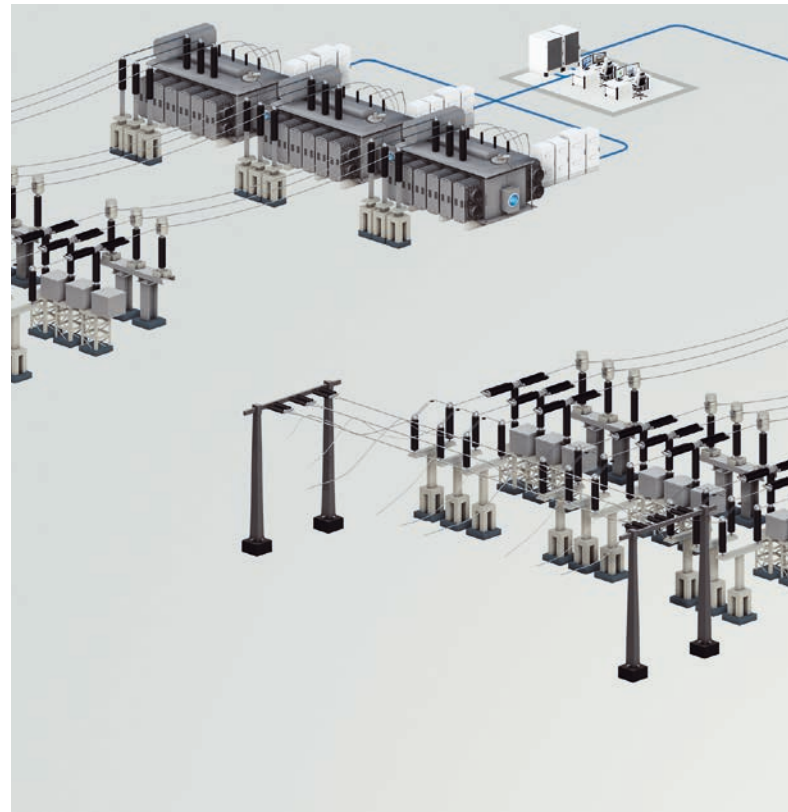
19" MCONTROL slot
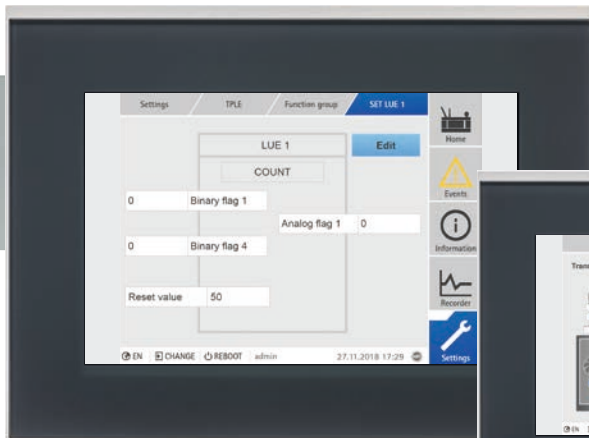
10" Example of TPLE surface MCONTROL

7" MCONTROL

TESSA®
ADVANCED ASSET MANAGEMENT.

The asset management requirements for electrical networks of generation, transmission and distribution companies as well as large industrial users are rapidly expanding and becoming increasingly complex.

TESSA® Fleet Monitoring provides you with a comprehensive tool for monitoring and evaluating your equipment and detecting faults early on. In short, it provides the optimal basis for an economical assessment of your transformer fleet.

Our software solution for intelligent asset management:
Combine TESSA® Fleet Monitoring with ETOS® and expand the operation and maintenance strategy of your high-voltage transformers – for the benefit of your transformer fleet.

As an intuitive browser application, TESSA® Fleet Monitoring offers you the following functionalities:
❚ Central data storage
❚ Visualization and analysis in accordance
   with industry standards
   – Time-series diagrams
   – Tap-changer monitoring
   – Gas-in-oil analysis
   – Bushing monitoring
   – Cooling-system monitoring
❚ Events, alarms and trends
❚ Comprehensive condition assessment

TESSA® Fleet Monitoring is hosted at MR based on the latest security standards and is compatible with a variety of sensors and industrial protocols, regardless of manufacturer.
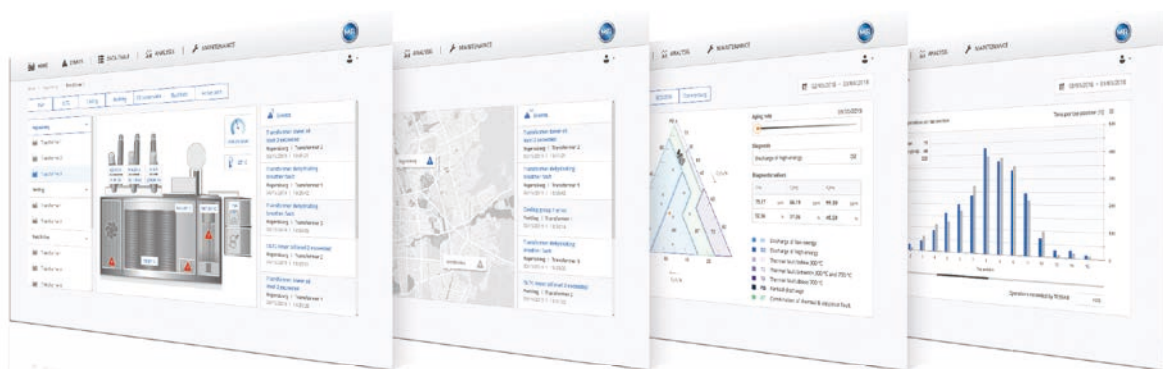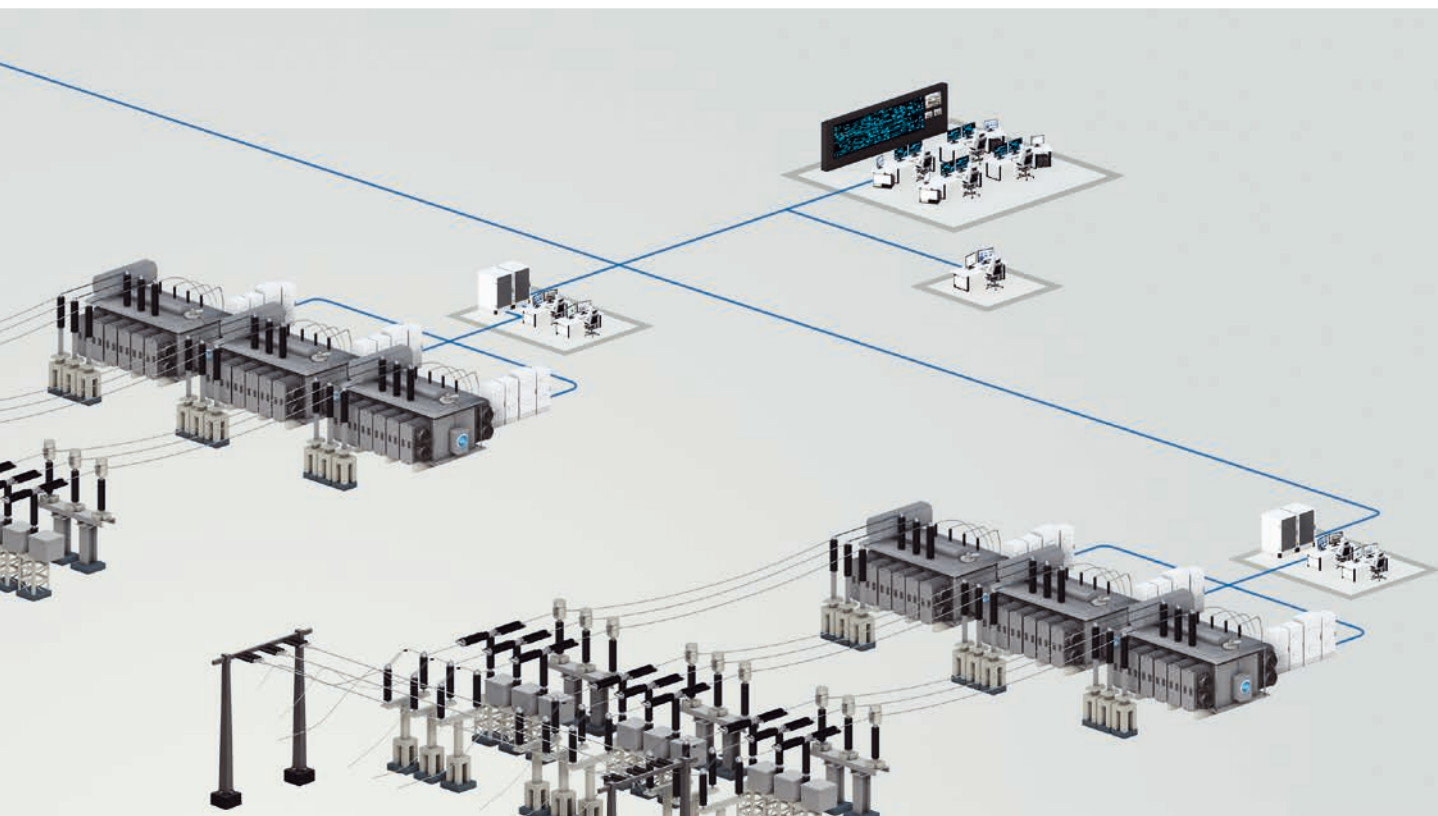
Your advantages at a glance:

The use of TESSA® Fleet Monitoring revolutionizes your maintenance strategy:

❙ Simple data management for the implementation of ISO 55000
❙ Increased transparency through globally recognized analysis functions
❙ Maximum operational reliability through early detection of trends and critical events
❙ Cost savings in maintenance and purchase of new equipment thanks to accurate assessment
❙ No effort for your IT administration, MR takes over the hosting for you
❙ Modular system, easy integration of ETOS® and MR sensors

MAKING CYBER SECURITY A CERTAINTY.

Security is the top priority in energy supply. This is especially true for the area of cyber security. That is why this was one of the most important aspects in the development of ETOS®. We offer a state-of-the-art solution – from the product architecture to support.

STATE OF THE ART

Security by design
❚ Consideration of IT security even in the design phase of ISM®

External audits in accordance with BDEW

Secure development process

Involvement of standard and committee work

PRODUCT ARCHITECTURE

Pre-configured, integrated firewall in accordance with IEC 62443
❚ Availability through network segmentation and reduction of engagement points

SSL/TLS (HTTPS) encryption (256-bit) in accordance with BSI TR 02102
❚ Validation of authenticity, integrity and confidentiality of the communication (RSA and ECC in accordance with NIST)

Security log for saving security-related changes
❚ Login, logout, changing values and settings, import, export configuration changes, event acknowledgement, etc.

"Role-Based Access Control (RBAC)" role-based user management in accordance with IEC 62351
❚ Integrity and confidentiality of the data on the device
❚ Need-to-know principle and separation of duties

Central user authentication in accordance with RADIUS as per RFC 2865

Password management in accordance with NERC-CIP
❚ Password complexity
❚ Encrypted password storage in accordance with FIPS-PUB 180-4

Defense in depth
❚ Fortified, robust operating system (VxWorks 5)
❚ Optional interface control: Ability to deactivate non-essential hardware interfaces
❚ Communication switch (Forwarding communication, redundancy RSTP/PRP)

Integrity of firmware, software and data
❚ Every version of the ISM® firmware is created using cryptographic methods and reviewed for integrity when installed. This ensures that only approved software versions can be implemented as protection against tampering

SUPPORT

Explicit customer interface for IT security
❚ Product security management by the CERT team
❚ Proactive management of weak points
❚ Recommendations and support in case of IT security questions

MANY ADVANTAGES.
ONE SYSTEM.

ETOS®. The smart path to an intelligent transformer.

Maximum Operational Reliability

❚ Automated monitoring of all equipment in real-time, 24 hours a day, 7 days a week
❚ Central database with trend monitoring and equipment comparison
❚ Active asset management support through a state-based maintenance strategy
❚ Increased equipment service life
❚ Errors are detected before a fault occurs
❚ Automated service notification (24/7)
❚ Central visualization of all connected transformers
❚ Guarantees a detailed analysis in the event of a fault

Cost advantages

❚ Significantly lower investment costs of a modern connection of ETOS® to the control
  point by means of network protocol (fiber-optic cable) instead of a conventional
  connection via copper cables
❚ Cost-effective elimination of defects at an early stage rather than costly repairs after the fact
❚ Savings with regard to service activities thanks to factors such as extended maintenance
  intervals and reduced need for system inspections
❚ Increase in equipment service life
❚ Bundling of functions at the transformer without additional costs
❚ Savings across the transformer manufacturer's entire value chain

Easy and fast integration

❚ Existing communication structure and devices can be used
❚ Optional connection and analysis of information provided by the control system
❚ Integrated document management and archiving
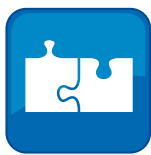
Reduction in complexity

❚ 1 system from 1 source
❚ Easy integration into existing infrastructure
❚ Simple connection of sensors and data sources from all manufacturers
❚ Easy to expand

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THE POWER BEHIND POWER.