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 provide 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

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
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 types, 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

**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

With ETOS® (Embedded Transformer Operating System), we provide an open system solution for reliable monitoring, control, regulation and digitalization of power transformers.
MAXIMUM DEPENDABILITY. MAXIMUM VERSATILITY.

NETWORK CONTROL ROOM

CONTROL LEVEL
Superordinate visualization and control of the transformer fleet

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

PROCESS LEVEL
Sensors and protective devices on the transformer

IT IS POSSIBLE TO CONNECT SENSORS FROM OTHER MANUFACTURERS

MESSKO® BETECH
Temperature monitoring

CONVENTIONAL
CONNECTION OF SENSORS BY MEANS OF STANDARDIZED INTERFACES

STANDARD CONTROL-SYSTEM PROTOCOLS

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

SENSORS BY MEANS OF STANDARDIZED INTERFACES

LEVEL MONITORING:

- MESSKO® MTO, MESSKO® MMK

INTELLIGENT SENSORS:

- MSENSE® DGA
  Online DGA monitoring

- MSENSE® BM
  Bushing monitoring

- MESSKO® MTEC EPT303 FO
  Temperature measurement via fiber-optic cable

- RS2001 OLTC
  Protective relay

- MTRAB®
  Maintenance-free dehydrating breather

- MESSKO® MSAFE®
  Buchholz relay

- MESSKO® MPREC
  Pressure relief device

- MESSKO® MFLOC 2.0
  Flow indicator

PROTECTIVE DEVICES / ACCESSORIES

ALL COMMON CLOUD SYSTEMS (OPTIONAL)

SCADA SYSTEMS (PROTOCOLS)

TESSA® FLEET MONITORING (OPTIONAL)
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 for monitoring hydrogen, carbon monoxide and moisture in the insulating oil
- MSENSE® BM bushing monitoring for condition monitoring of the bushing insulation
- MESSKO® MTEC EPT303 FO for measuring the winding temperature directly at the source

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

- MTRAB® 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
FIELD LEVEL

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
- 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
- Tried and tested 10,000 times in our TAPCON® products

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

ETOS® DESIGNS

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

ETOS® ED
- Classic drive technology (with a mechanical linkage)
- Standalone variant in the control cabinet

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

AVAILABLE PACKAGES

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■ Package in a basic version ■ Extended function package
OPEN TO ALL. OUR MODULE BLOCKS.

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 the oil 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**
- Number of starts per cooling level
- Operating time per cooling level
- Monitoring of $R_\text{th}$ and cooling efficiency

**Cooling system control**
- Freely adjustable switching points, hysteresis and delay times
- Various control algorithms
  - Periodic cooling group activation or
  - Predictive cooling
- Fail-safe mode

*) contained in every ETOS® design

**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
- ETOS® ED: OLTC torque monitoring
Field Level

**Voltage Regulation**

- **Standard functions**
  - Measurement of system voltage and load current (single- or three-phase)
  - One desired value
  - Voltage regulation with linear delay time $T_1$
  - 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 $T_1$ and $T_2$
  - 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 ten corrosive 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

**Bushing monitoring**

- Monitoring of changes in $C_1$ capacitance
- Monitoring of the dissipation factor ($\tan \delta$)
- System voltage

**ETOS® Embedded Transformer Operating System**

**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

**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.

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 made from lined aluminum sheeting supports passive cooling, application possibilities for all climate zones
- Easy on site operation with integrated LED lighting, laptop holder, socket and service interface

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**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 ASCII, 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
Our fleet monitoring solution is called TESSA®. It offers operators of electrical energy networks a comprehensive tool for monitoring and evaluating their equipment and for detecting trends or faults at an early stage, thereby providing a basis for analyzing the economic efficiency of their fleets.

TESSA® allows your electrical equipment to be monitored globally. You receive all the information you need for ideal condition assessment and implementation of your maintenance strategy. TESSA® integrates various online data sources by means of standardized control system protocols. The recorded data is stored in a central database for further analysis and archiving. Overview information and detailed analyses (gas-in-oil, tap changer and bushings) are consistently displayed. TESSA® fleet monitoring also detects gradual changes and indicates them in a timely manner.

Our system meets all security standards for protection against unauthorized access. In the event of a critical incident, the system can send a warning by e-mail or text message. TESSA® fleet monitoring can be accessed directly via a web browser, without the need to install additional client software.

Users of TESSA® fleet monitoring have two hosting variants to select from:

- Use of our MR server in accordance with the latest security standards (cloud solution)
- Delivery of an industrial PC with installed and preconfigured software (on-premises solution)
Your benefits at a glance

- Automated monitoring of all equipment (24/7)
- Manufacturer-independent integration of all equipment using standardized protocols (IEC61850, Modbus RTU, Modbus TCP, DNP3 and others)
- Intuitive overview and data analyses of gas-in-oil, tap changer and bushings
- Central database and algorithm for trend monitoring
- Utilization of the existing communication structure (OT and IT) as well as the field devices used on site
- Indication of defects at an early stage to prevent cost-intensive repairs
- Savings thanks to extended service life of the equipment and condition-based maintenance
- Active support of asset/service management thanks to clear information and recommendations
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**
- **"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**
- **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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