AUTOMATING POWER TRANSFORMERS

INTELLIGENT MONITORING, CONTROL AND REGULATION.

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Benefits of automating power transformers:

- Operating reliability through effective control and prevention of faults
- Cost optimization through condition-based maintenance and functional integration
- Standard of the future in terms of reliability and regulatory requirements
The growing number and greater average age of power transformers and increasingly more demanding technical requirements of monitoring, control and regulation are presenting growing challenges for the work of asset managers and grid management. The decision making process is often impaired by unplanned outages, increasing expected useful life of the equipment and loss of knowledge. In order to efficiently operate and maintain existing systems and prevent critical errors on power transformers, the right equipment must be present, work together smoothly within the system and provide the best possible support for existing control and maintenance processes.

MR provides modular system solutions for various types, power rating classes and models of power transformers. We also have decades of experience in the control and monitoring of power transformers.

Our system for automating power transformers comprises monitoring and safety equipment, (intelligent) sensors, field devices for control, regulation and monitoring, superordinate fleet monitoring, and all the accessories needed for attachment and communication. We provide solutions for all transformers from all manufacturers, regardless of age and location – for one transformer or an entire fleet. The sub-components are split into the process level, field level and control level.

What makes this setup so special is how the components easily connect in the system, making simple, individual and customized design possible. User friendliness during integration and subsequent operation are very important to us. We can also extend or modernize your existing power transformers with ease, enabling the transformers to be effectively controlled and monitored – for maximum availability and reliability.

From initial assessment on site and consulting to project planning, delivery and commissioning, we would be delighted to automate your power transformers – put us to the test!
YOUR ONE-STOP SHOP.
FROM THE VERY START.

From initial assessment and training of your personnel to subsequent expansion – our experts are at your disposal during every step of your project and even beyond.

**Initial assessment on site**
- Inspecting the facilities
- Recording the condition of the power transformers
- Noting the available sensors
- Establishing the need for new equipment and/or retrofits (sensors, protective devices, field devices and communication)
- Checking other interfaces and data sources, such as the integration of control system information
- Clarifying communication paths/routes: Using pre-existing paths or planning the development of a parallel communication path

**Consulting**
- Developing detailed strategies for the entire system
- Carrying out measurements on equipment (optional)
- Defining project stages
- Proposing recommended actions for power transformer control and monitoring
- Analyzing and producing (communication) security concepts

**Implementation**
- Procuring additional sensors and installing them on the power transformer
- Configuring and installing monitoring systems
- Setting up and networking secure communication paths
- Configuring the TESSA® central monitoring system based on customer requirements and system conditions and installing on site

**Commissioning**
- Checking wiring and communication paths
- Checking monitoring systems for functionality and data transmission from sensors
- Connecting monitoring systems to control systems
- Transferring system documentation
- Carrying out training for operating personnel

**Further support**
- Assisting in equipment evaluation and decision making
- Integrating additional data sources or sensors
- Periodically checking system integration and databases
- Analyzing the products used for any adjustments needed (e.g. new functions, operating systems for security updates) and assisting with any updates undertaken
CONTROL. REGULATE. MONITOR.
WITH INTELLIGENCE AND MODULARITY.

Superordinate visualization of the transformer fleet

Visualization with remote operating panels in the station building

Control, regulation and monitoring in control cabinets, fitted on the transformer

Solution for integrating in the MR motor-drive unit

Conventional sensors possible.

CONVENTIONAL SENSORS
Standard communication protocols (e.g. IEC61850)

**CONTROL LEVEL**

**FIELD LEVEL**

**TESSA® FLEET MONITORING**

**PROCESS LEVEL**

**INTELLIGENT SENSORS**

**PROTECTIVE DEVICES / ACCESSORIES**
RELIABLE IN THE LONG TERM. AND THAT’S GUARANTEED.

Monitoring and safety equipment, conventional and intelligent sensors – the perfect jobs for our tried and tested MESSKO® brand.

Testing, measuring, analyzing, evaluating – our MESSKO® brand is synonymous with these areas of work. The MESSKO® and MSENSE® product brands are defined by their endeavors to achieve precision and perfection. The products for the monitoring, protective, control, regulation and automation technology associated with transformers make energy providers and industrial companies fit for the future and ensure that their systems run smoothly and reliably even under the most demanding conditions.

Conventional sensors

Temperature monitoring and display

Continually monitoring temperature is one of the most important actions for ensuring a transformer’s functional capability and readiness for operation. Two thermometer technologies have developed over the decades and are still used today – the Bourdon principle and the expansion bellows principles. MR customers can benefit from obtaining both proven technologies from one source. The MESSKO® BeTech range of thermometers uses the respected expansion bellows technology, while the MESSKO® COMPACT and MESSKO® TRASY2 ranges are based on the Bourdon principle.

The MESSKO® COMPACT range includes two types of temperature-measuring instruments. These small and compact instruments contain everything needed for measuring temperature, displaying measured values, reporting alarms and remotely transferring the measured value – and do so without any additional devices!

The MESSKO® TRASY2 range of thermometers was developed specially for temperature measurements (oil or winding temperature) in distribution and power transformers. The MESSKO® TRASY2 range is an indicator thermometer which works independently and has its own energy supply. Using its micro-switch, it is able to handle various switching tasks. Like the MESSKO® COMPACT type series, this thermometer is also fitted with freely adjustable micro-switches.

Level monitoring

Oil level indicators of the MESSKO® MTO type range display the oil level in the transformer’s expansion tank. Keeping the sensor and display unit separate prevents the oil from being able to escape from the expansion tank. The oil level is monitored continuously and operating errors are avoided – especially when filling the transformer.

Magnetic oil level indicators of the MESSKO® MMK type range enable the level to be displayed without having to place a floater in the tank. The magnetic flap indicator can be easily fitted onto existing flange connections (retrofit) in accordance with DIN 42 552 and is an adequate substitute for the temperamental glass tube display.
**Process Level**

**Benefits for you:**
- Robust and durable products
- For new transformers or for retrofitting
- Thorough analyses, individual consulting and first-class support

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**Protective devices**

The maintenance-free MESSKO® MTraB® dehydrating breather is used in oil-insulated transformers, reactors and tap changers to remove moisture from the air drawn into oil conservators. The incoming air is fed over the drying agent (silicate gel) and dried. The MTraB® monitors moisture levels and itself. The status is indicated using signaling contacts.

The MESSKO® MSafe® Buchholz relay is used as a central protective device for liquid-filled transformers and reactors with expansion tanks. It triggers if gas accumulates or if there is a sudden increase in flow speed, as well as in the event of oil loss. This prevents potential damage to the transformer at an early stage.

The RS2001 protective relay is designed to protect the on-load tap-changer and transformer from faults inside the on-load tap-changer and/or selector-switch oil tank. It activates when the specified speed of oil flow between the on-load tap-changer head and oil conservator is exceeded due to a fault.

The MESSKO® MPreC® pressure relief device is designed for transformers and on-load tap-changers should the pressure in the oil system rise. If the permissible valve activation pressure is exceeded, the device opens within milliseconds.

The MESSKO® MFloC® flow monitor monitors the flow of coolant in the oil-water cooling circuit of transformers. It reliably recognizes and reports pump failure in an instant. There are two micro-switches (change-over switches) permanently fitted for electric signaling.

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**Intelligent sensors**

MSENSE® DGA uses the hydrogen, carbon monoxide and moisture levels in the insulating oil of power transformers to monitor for primary early indicators of potential thermal or electrical damage to the transformers. Continuous functional safety and reliable measured values are ensured through components which are as robust as they are technically refined and through the new two-level measurement procedure deployed in the oil flow itself.

The MSENSE® BM bushing monitoring uses an innovative and field-tested double reference method (2/3 reference method) that monitors the condition of the bushing insulation in terms of a change in capacitance (C1) and dissipation factor (tan δ) in a three-phase system. The key aspect of this process is that, since the algorithm continuously incorporates all three bushings into mutual monitoring, the temperature dependence of other processes is eliminated. Furthermore, the signals of the respective voltage transformers are used as a reference for detecting the symmetry of the three-phase system. The measurement is checked for validity and grid asymmetries are effectively equalized and eliminated. By cross-checking the three phases, the double reference method ensures that the influence of temperature and voltage fluctuations on a bushing monitoring system are effectively limited.

The MESSKO® MTeC EPT303 FO measures the winding temperature directly at the source and communicates using TCP protocols. Up to 32 innovative MESSKO® MSpot® glass-fiber sensors are fitted directly in the transformer's windings and measure the hot spot temperature at the source with incredible accuracy.
MAXIMUM OPENNESS. MAXIMUM VERSATILITY.

Reliable devices with functions for controlling, regulating and monitoring power transformers.

In our flexible and modular TRAFOGUARD® field devices for controlling, regulating and monitoring the power transformer, you can individually choose from various packages of options to suit your needs. Various designs and possible uses are available. TRAFOGUARD® has a maintenance-free and standardized hardware and software basis used for all MR automation solutions. The hardware components and the universal software architecture are renowned for their user-friendliness and flexibility. The system is, of course, designed to meet the special requirements of energy technology with regard to reliability, robustness and durability. TRAFOGUARD® is designed to be open and flexible, thereby supporting both the use of configurable standard products as well as the implementation of individual requirements in transformer substation automation. Regardless of the application, users benefit from standardized components, tools and operating interfaces.

To improve transformer reliability and prevent unscheduled failures and critical errors, we provide power transformer monitoring that supports modular configuration. Control and regulation functions can be integrated too.

To monitor these components online, we provide individual functions, which can be configured based on the application, importance and power rating class of the transformers. While small distribution transformers tend to need temperature and power monitoring, it is important for large grid-connection and power-plant transformers to have sufficient monitoring of all components with a high error-detection rate. Customers can select from the following packages:

**MONITORING**

*Transformer monitoring*

The temperatures, power levels and signals of additional sensors and protective devices are monitored. In addition to assessing limit values, we also offer calculation models to monitor the hot spot temperature, bubbling temperature and ability to cope with overload. The standard package forms part of the basic functions provided for all transformers.

*Online DGA*

Online DGA sensors are state-of-the-art technology for monitoring the active part, especially in the winding. Through their use, thermal or electrical errors can be detected at an early stage and remedial steps can be taken to avoid critical failures. TRAFOGUARD® can integrate DGA sensors using 4...20 mA or Modbus RTU and interpret the concentrations of gases. Standard analysis methods such as Duval and Rogers, for example, are available.

**Sources of error on power transformers**

- 45% windings
- 26% on-load tap-changers
- 17% bushings
- 12% other
Bushing monitoring

For electrical field grading, high-voltage bushings above a certain voltage level are almost exclusively equipped with capacitive grading layers. These are exposed to high electrical, thermal and mechanical loads during operation. In order to detect errors early on and prevent damage to the greatest extent possible, the condition-relevant variables of capacitance (C) and dissipation factor (tan δ) are monitored directly on oil-impregnated (OIP) or resin-impregnated (RIP) paper bushings of voltage levels of between Uₘₐₓ = 123…765 kV.

OLTC monitoring

On-load tap-changers can be monitored online using various methods. For example, maintenance intervals can be calculated individually on the basis of switching conditions, especially for oil-based tap changers. This ensures condition-based maintenance and therefore efficient asset management. Temperatures, switching statistics and torques can also be monitored for all tap changers.

CONTROL AND REGULATION

Voltage regulation

Voltage regulation can be selected as a function. For this, we provide various packages of options, which are already being used in our TAPCON® products, tens of thousands of which are in use around the globe. In addition to simple voltage regulation, various parallel operation methods and complex regulation algorithms can also be used.

Cooling system control and monitoring

The cooling system can be monitored to undertake condition-based maintenance. This involves observing cooler starts and cooling efficiency. The intelligent cooling system control observes the current load conditions and thermal transformer circumstances and, based on its findings, regulates the temperature for up to six cooling stages.

OPTION PACKAGES CAN BE SELECTED FOR CONTROL, REGULATION AND MONITORING

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Standard

Advanced

☑ Standard
☐ Optional function package (configurable)
TRIED AND TESTED MODULES FOR A LONG TRANSFORMER LIFE.

Efficient transformer control and monitoring. Modular packages can be put together individually.

### Transformer monitoring

**Standard**
- Status monitoring of protective devices (e.g., RS2001, Buchholz relay, PRD)
- Monitoring of 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**
- 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

### Voltage regulation

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

**Advanced**
- Various types of desired-value setting (3 or 5 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 (R-X or Z compensation)
- Monitoring of bandwidth
- Function monitoring
- Limit-value monitoring

### OLTC monitoring

**Standard**
- 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**
- Motor current index in accordance with IEEE PC57.143
Cooling system monitoring
- Number of starts per cooling level
- Operating time per cooling level
- Monitoring of Rθ and cooling efficiency

Cooling system control
- Switching points, hysteresis and delay times adjustable to your needs
- Various control algorithms
  - Periodic cooling group activation or
  - Predictive cooling
- Fail-safe mode

Additional functions
- DIO configuration – freely programmable digital inputs and outputs
- AIO configuration – freely programmable analog inputs and outputs
- TPLE – programming function with function blocks

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
TRAFOGUARD® can be configured in various designs and housings to be fitted on any transformer. Our complete range covers consultancy, configuration, choice of appropriate design and engineering of the control cabinet.

Fitting TRAFOGUARD® directly on the transformer allows the captured data to be transferred directly to the control station via network protocol using a fiber-optic cable. This greatly reduces the amount of wiring needed during installation and significantly cuts costs compared to a conventional connection method.

Modular and efficient hardware design

**Hardware**
- Modular and efficient hardware design
- Specific modules for various tasks, such as measurement or communication
- Supports all common interface standards
- Ambient temperature during operation -25 °C to +70 °C
- Various voltage supplies with wide-range power supplies

**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)

**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)

The three designs:

- Solution for integrating in the MR motor-drive unit
- Standalone variant in the control cabinet
- Solution for integrating in a customer control cabinet (plug-in modules)
We provide various displays for visualization (MMI). They come in various sizes and for various conditions (outdoor use, indoor use). The TRAFOGUARD® visualization is matched perfectly to the user and can be operated intuitively using modern graphic elements. This makes the system easy to configure and operate. The visualization is prepared 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.

With TPLE (TRAFOGUARD® Personal Logic Editor) you can program simple logic functions. Thereby processes can be easily adapted, optimized and developed.

**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, which are available in client or server functionality
- Customization with flexible digital and analog inputs and outputs, which can be programmed by the user
The TESSA® fleet monitoring software allows your equipment to be monitored globally. All the data you need for ideal condition assessment and implementation of your maintenance strategy is displayed precisely and clearly. The equipment information is digitized by the TESSA® system integrator, allowing various online data sources to be connected to TESSA® using standardized control system protocols. The combined integration of online and offline data, such as laboratory and maintenance reports, thereby makes comprehensive asset management possible. The recorded data is then stored in one common, central database for subsequent analysis and long-term archiving. Direct system access to the intuitive, user-friendly visualization of the integrated web server is possible using a web browser without the need to install additional client software on the customer’s end devices. The system satisfies all the necessary security standards for protection against unauthorized access. Important information, such as the maintenance status or the utilization of individual transformers, is displayed centrally and clearly. In the event of a critical incident, the system can send a warning by e-mail or text message. This allows for quick troubleshooting in an emergency. But TESSA® also detects gradual changes reliably and indicates them on the integrated trend display in a timely manner.

Three different hosting options are available for the TESSA® fleet monitoring system:

- Delivery of an industrial PC with installed and preconfigured software (on-premise solution)
- Use of your existing server (on-premise solution)
- Use of our MR server as a cloud solution in accordance with the latest security standards (cloud solution)

Benefits for you:
- Automated monitoring of all equipment in real-time, 24/7
- Central database with trend monitoring and equipment comparison
- 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

TESSA® fleet monitoring

![Diagram of TESSA® fleet monitoring system](image)

- Equipment assessment (math. & phys.)
- Alerting by e-mail or text message
- ERP SYSTEM
- Control system(s)
- Local access
- Remote access
- TESSA® FLEET MONITORING
- Central database
- Online/offline

Sensors and monitoring
MANY ADVANTAGES. 
ONE SYSTEM.

System supplier – from sensors to fleet monitoring.

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
- Enables a maintenance strategy based on knowledge and actual condition
- Guarantees a detailed analysis in the event of a malfunction
- Increases equipment service life
- Gradually arising errors are detected before they can cause disruption
- Automated service notification (24/7)
- Active asset-management support
- External regulations (e.g. by authorities) regarding documentation of assets can be fulfilled (data recording, event display, ...)
- Central visualization of all connected power transformers

Reduction in life-cycle costs
- 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

Easy 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