

TrafoNOVA

Global Transformer Monitoring System

TECHMP



Benefits of transformer monitoring

Condition assessment of power transformers is likely the most challenging task in asset management of transmission and distribution networks. This is due, on one side, to machine construction and complexity that makes, for instance, visual inspection very expensive and time-consuming.

On the other side, transformers are expensive and critical equipment, due to the long time needed to replace or restore them after a failure.

Moreover, catastrophic failures of a power transformer often involve fires and explosions, posing at risk operator safety, damaging other pieces of equipment, and polluting the environment.

Electrical installations are usually subject to **Time-Based Maintenance (TBM)** program at fixed time intervals. However, for the most critical equipment, **Condition-Based Maintenance (CBM)** is more advisable.

Applying CBM, means to keep the electrical equipment state under control.

This is done to detect potential sources of problems at a very early stage and to take the relevant countermeasures before irreversible and harmful events happen.

Through CBM, the failure rate is kept constant at the level chosen by the asset manager. Therefore, an unexpected breakdown that causes prolonged forced shutdowns can be avoided, thereby limiting costs due to loss of revenues and repair after a failure.

An **EFFECTIVE DIAGNOSIS** emerging from smart condition based maintenance can lead to:

- Reduction of the probability of unplanned outage
- Localization of the possible defect
- Trending of the aging process can be recorded

Causes of insulation degradation

During its life, the power transformer suffers from the impact of thermal, mechanical, chemical and electrical stresses.

The transformer condition gradually deteriorates, leading to:

- Reduction in dielectric strength: ability to withstand lightning and switching impulses
- Reduction in mechanical strength: ability to withstand faults, i.e., short-circuit currents
- Reduction of thermal integrity of the windings: the ability to withstand overload currents.

Oil Paper Transformers:

- Thermal degradation of:
 - cellulose (polymerization)
 - oil (oxidation, scission of polymeric chains)
- Partial discharges in paper-pressboard
- Corona discharges in oil
- Mechanical degradation associated with vibrations, short circuits

Resin Transformers

- Partial discharges
- Thermal degradation of resin (scission of polymeric chains)
- Mechanical degradation associated with vibrations, short circuits

The thermal process causing degradation of (detected by DGA)

- Cellulose (polymerization)
- Oil (oxidation, scission of polymeric chains)

Electrical problems causing (detected by PD)

- Partial discharges in paper/pressboard
- Corona (creeping) discharges in oil

Localized problems in bushings (detected by PD)

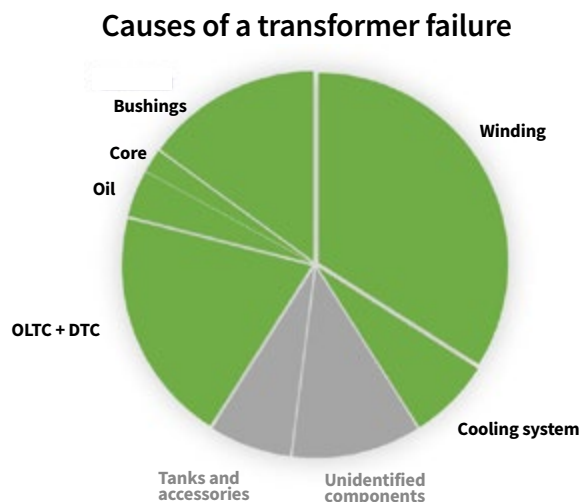
- Hot spots
- Constructional arrangements
- Small oil volume
- Assembling

Bulk problems in bushings (detected by capacitance/ $\tan\delta$)

- Dielectric losses due to absorption of moisture/water
- Bad assembling/connections

OLTC (On Load Tap Charger)

- Mechanical contacts
- Arcing



TrafoNOVA covers the 85% of the components that generate failures

TrafoNOVA - A modular system for different solutions

Power transformer plays a fundamental role in electrical power systems and represents significant investments involved in the implementation of these systems.

To reduce the costs associated with a transformer's life cycle and to guarantee its reliability and durability, it is essential to monitor its operating conditions, insulation system, and the working conditions of all its components.

TrafoNOVA - Global Transformer Monitoring System is able to support the asset manager's decisions on the predictive and

preventive maintenance actions on transformers.

TrafoNOVA - Global Transformer Monitoring System is a modular system that involves four different acquisition units: **EDS MK3, TD GUARD, PD SCOPE, and DGA**. The units can be used all together, for a global monitoring system, individually or in combination. Some parameters are strictly related to faults/defects, while others are stressing/enhancing factors for defects. All the measurements have a warning and alarm threshold in order to highlight the problem to the SCADA system and prevent failures.

Generic transformer parameters monitoring EDS MK3

- Line currents
- Oil temperatures (bottom, top, cooling system)
- Core and windings temperatures
- Cooling system current consumption (fan and pumps)
- Hot spot temperature according to IEC 60076-7
- Loss of life

Bushing monitoring TD GUARD 3

- Absolute Tan Delta (6 bushings HV & LV)
- Relative Tan Delta
- Bushing Capacitance measurement
- Leakage current of each bushing
- Tandelata degradation over time
- The fast change in bushing capacitance
- Measure the temperature of the bushing
- Bushings currents and current imbalance
- HV or LV Voltage (for TD calculation)

Dissolved gas monitoring DGA

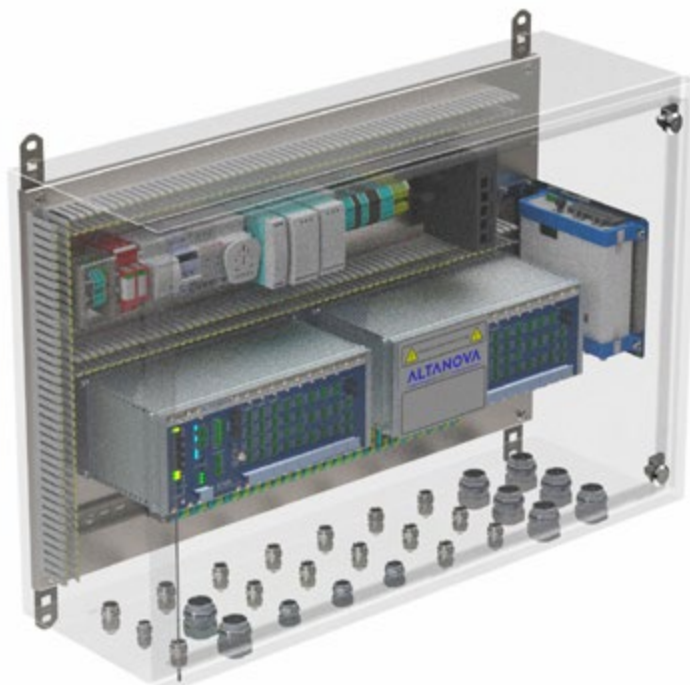
Detected gasses from 1 to 9(*), for instance:

- Hydrogen (H₂)
- Oxygen (O₂)
- Methane (CH₄)
- Carbon Monoxide (CO)
- Carbon Dioxide (CO₂)
- Ethylene (C₂H₄)
- Ethane (C₂H₆)
- Acetylene (C₂H₂)
- Nitrogen (N₂)
- Moisture-in-Oil
- Oil Temperature

(*) Depending on DGA requested by the customer.

Partial discharge monitoring PD SCOPE

- Partial Discharge
- PRPD Pattern
- T/F - Map
- Pulse shape
- Localization on arrival time



Generic transformer parameters monitoring - EDS MK3

EDS MK3 is a modular system configurable according to customer requirements.

On each module of EDS MK3 can be installed up to 10 (rack 3U 13") or 14 (rack 3U 19") cards and each card is designed to measure specific parameters:

- PT100: temperatures measurement. Up to 4 PT100 each card
- I²t: currents measure (line currents or fan or pumps). Up to 4 currents each card
- 4...20 mA: for DGA (single gas & moisture), ambient temperature, etc.

EDS MK3 is also equipped with a communication card, to be connected to a SCADA system.

The card includes: two different fiber ports to support a ring connection to the server, IP address setup, PC board, monitor, ethernet and USB ports for diagnosis and commissioning.

Bushing monitoring - TD GUARD3

TD GUARD3 monitoring system for Bushing Tandelta allows up to 12 channels (six bushings and 6 CVT).

Depending upon the configuration of TD GUARD3, two different measurements levels are defined: BASIC and ADVANCED.

BASIC

- Leakage current of each bushing
- Detect Tandelta degradation over time
- Detect fast change in bushing capacitance
- Measure the temperature of the bushing

ADVANCED

- Absolute Tandelta (6 bushings HV & LV)
- Relative Tandelta
- Bushing Capacitance measurement
- Leakage current of each bushing
- Detect tandelta degradation over time
- Detect fast change in bushing capacitance
- Measure the temperature of the bushing

Partial Discharge monitoring PD Scope™

The high performance partial discharge diagnostic system, as the heart of every permanent monitoring system, the PDScope™ will be connected to 3 or 6 PD sensors via coaxial cables and will acquire the HV signals coming from the PD sensors. Each PDScope™ is provided with a 100 MS/s acquisition system, with three independent channels, a synchronization channel and with a standard Ethernet 10/100 Mb interface. The system is based on a large memory large bandwidth digitizer for acquisition purposes.

It acquires the entire waveforms of a large number of detected signals, so that the system will be able to characterize pulses, to improve signal to noise ratio and to derive pulse feature for signal separation purpose. The fundamental innovation of TECHIMP PD diagnostic system consists of the acquisition and processing philosophy.

Per each acquired pulse the acquisition unit automatically calculates its equivalent time and equivalent frequency content, building the so-called "T/F - Map" or "Classification Map".

TrafoNOVA exploits the Time-Frequency analysis of the signals (T/F - Map), which allows effective separation of different signal sources. Three clusters are identified in the T/F - Map: background noise, internal discharges and surface discharges.

Central Unit with TiSCADA™ Monitoring Software Suite

The acquisition unit located at the transformer has an onboard data storage which can be downloaded to a laptop anytime. However, the unit usually will be connected to a central server, which can range from an industrial PC to a high performance 19" - industrial server unit with watchdog and UPS on which the TiSCADA™ monitoring software suite will run. As an alternative the TiSCADA™ monitoring software suite can be supplied on a virtual machine, which can be operated on an existing server. Data can be sent from the server to a substation SCADA system via IEC61850, IEC60870-5-104, OPC UA, and other protocols.

A sample of a high-performance server configuration could be:

- Industrial rack 42U
- Industrial server unit
- Watchdog unit & managed ethernet switch
- 17" LCD monitor + keyboard (rack-mounted)
- UPS unit
- TiSCADA™ Software Suite



TAP ADAPTER



TD SENSOR

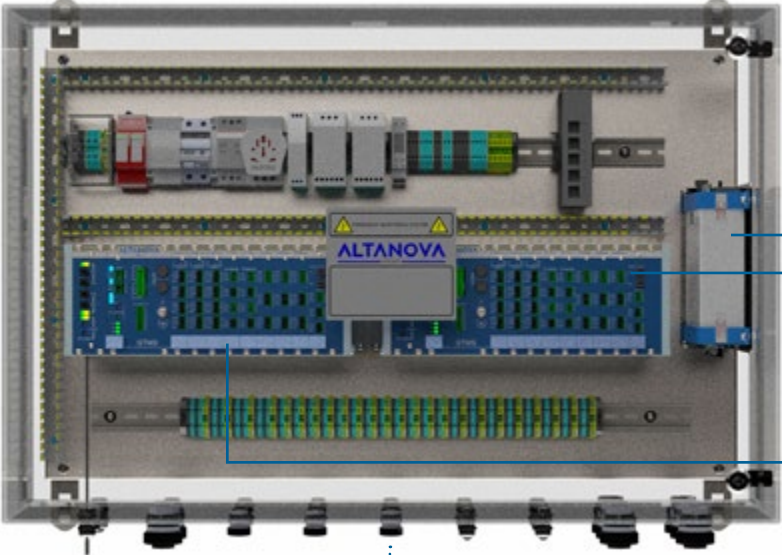


UHF SPIRAL ANTENNA



DGA

TrafoNOVA HUB



PD SCOPE



EDS MK3



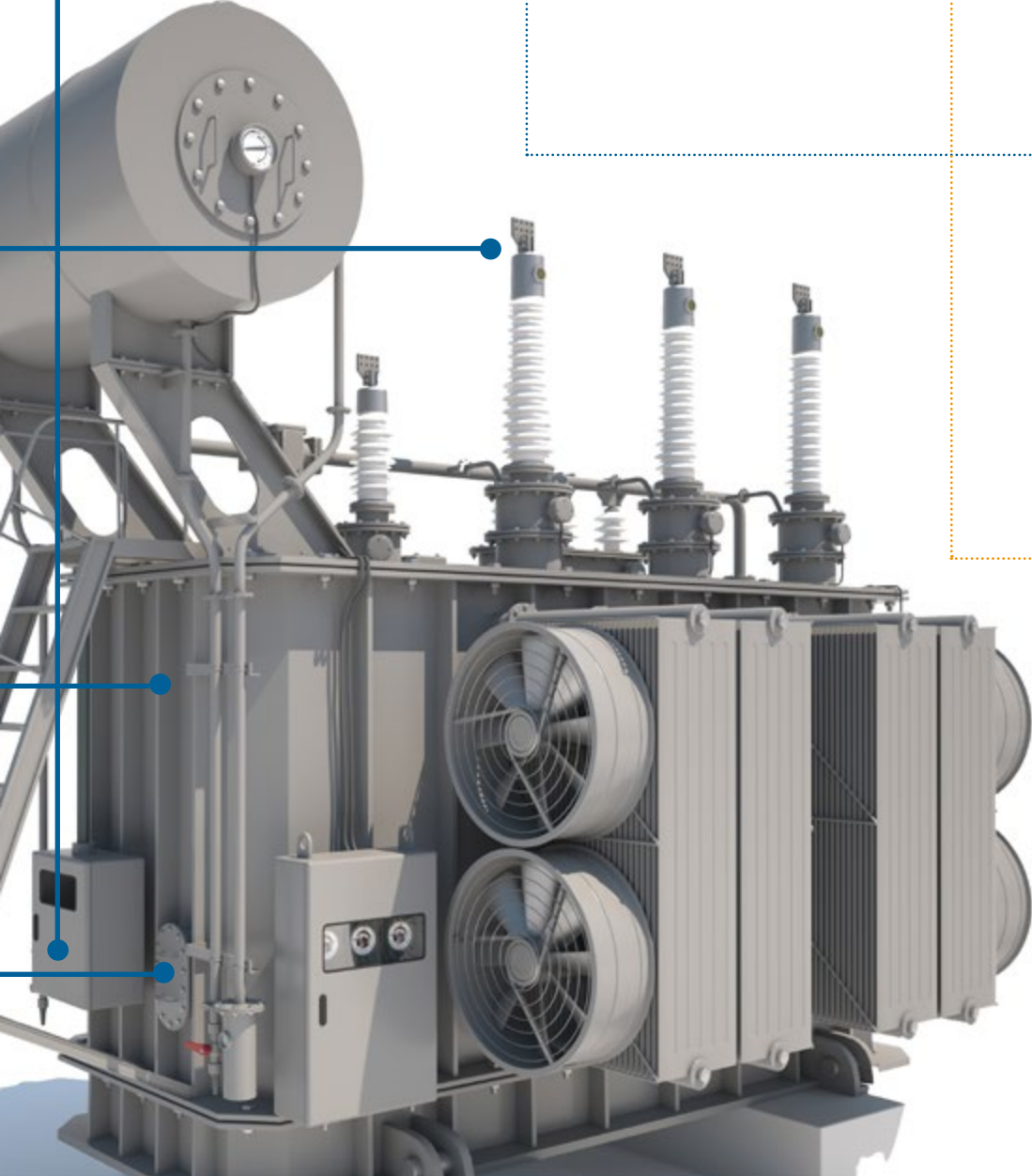
TD GUARD3



CENTRAL UNIT WITH TISCADA



WEB SERVER INTERFACE



Partial Discharge & Tan Delta Sensors



TD Sensor

TD Sensor has been designed to measure leakage currents and to carry out impedance measurements through a capacitive divider. It is installed between the tap adapter connected to the bushing and the guard. It has a double function: it conditions signals received from the Tap adapters and implements three protection levels for bushing safety. Thanks to the multiple levels of protection, ground connection is always ensured, and the safety of the monitored asset guaranteed, increasing at the same time, the reliability of the tan-d sensor.

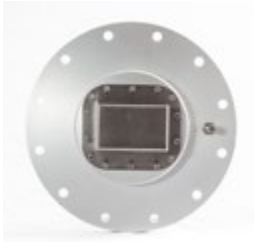
Bushing Tap Adapter

Tap Adapter connects to the test tap (sometimes called power factor tap) of the transformer bushings. Tap Adapter is suitable for **online measurement and permanent online Partial Discharge and/or Tan Delta monitoring**. While keeping the test tap well below the safety voltage level required by the manufacturer, the Tap Adapter acquires high-frequency Partial Discharge signals for diagnostic assessment of insulating materials. Although it must be customized according to the shape and dimension of the test tap (to be provided by the customer), many models are readily available for the most established transformer bushings.



PD Sensors

The PDScope™ partial discharge acquisition unit is usually connected to the Bushing Tap Adaptors or to the UHF sensors.



UHF Sensors

UHF PD sensors are designed to receive electromagnetic (EM) emissions from a Partial Discharge. UHF sensors can be installed as spiral antennas at special dielectric windows distributed around the tank provided by the transformer manufacture and/or as drain valve sensors into the oil valve. The UHF sensor is a broadband antenna with a flat response which makes the Spiral antenna suitable for different applications. It has been optimized to operate in a frequency range typical for PD activity and it was designed to provide maximum sensitivity and high gain.

DGA Sensor

is an online monitoring sensor for Dissolved Gas Analysis. It monitors from 1 up to multiple gasses. We can supply a DGA unit at customer choice or connect to an existing DGA installed by the customer.



Web Server



All the measurements are available through a local web server on EDS. This easy way (through TCP/IP) to access to the measurements can also be used if the monitoring system is not connected to the substation SCADA.

It is possible to configure the web server to display only the available measurements, avoiding the creation of different executables for each project.

An example could be the following configuration:

- Overview
- Main tank
- Cooling
- DGA
- Bushing HV
- Bushing LV
- Alarms

TrafoNOVA technical specification

EDS MK3	
Power supply voltage	110 V DC nominal; acceptance range from -30% to + 10%
Absorption	100 W
Communication	Ethernet port with TCP / IP protocol, intended for system configuration and maintenance connectors screw on DIN rail (in case of IP54 enclosure supply)
Input connectors	Screw on DIN rail (in case of IP54 enclosure supply)
LAN connection	ST fiber optic connectors multimode 62.5 / 125 micron
Malfunction signal	Power supply failure
Hourly synchronization	IEC 60870-5-104; Time real-time clock (in case of temporary interruption of the external sync)
Web user interface	Web-server
Dimensions	3U x 13"
Degree of protection	IP 20
Data processing	PC Cortex A9 dual-core CPU 1 GHz; DSP BF537 Analog devices; FPGA A3P600 Microsemi
Data Storage	One micro SD card slot
Memory	512 SDRAM, 1Gb Flash

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PD SCOPE	
PD Channels	3 based UWB Channels (expandable to 6 or 12)
Bandwidth	16kHz-30MHz, built-in UWB filter (extendable to 1GHz with external Frequency Shifter, installed in the PDHub)
Resolution	10 bit
Input Impedance	50 Ohm
Recording time length	1 μ s (min) 20 μ s (max)
Connectors type	BNC

Tap Adapter Sensor

Voltage output @ 50Hz or 60Hz	1 ÷ 10Vrms
Max output transient voltage	90Vpeak
Vout vs Vin phase shift	90°
Operating temperature	-25°C ÷ +65°C
Output connector	BNC
Protection degree	IP66
Current to ground @ 50Hz or 60Hz	Below 10mApC

UHF Spiral Antenna

Bandwidth	500MHz – 3GHz, stand-alone sensor (Techimp Frequency Shifter recommended)
Typical VSWR	2:1
Polarization	Circular
Impedance	50 Ohm
Overall Dimensions	340 x 340 x 175 mm (or customized)
Weight (without the RF cable)	3 kg
Connector	Type N
Power Supply	Only for optional devices (frequency shifter)
Installation	In the proximity of EUT apertures
Operational limits	Env. Temp: -20-65C; Env. RH: 0-100%

International Standards

STANDARD	TYPE OF TEST
EN 60529+A1+A2	Degrees of protection (IP code)
EN 61010-1	Safety requirements for electrical equipment
EN 61000 - 4 (-2/-3/-4/-5/-6/-8/-11/-16/-17/-18/-19/-29/-34) EN 61000 - 6 (-2/-4/-5)	It contains specifications for Electromagnetic compatibility, like: - Electrotechnical Commission's immunity standard based on electrical fast transient (EFT) / burs transients - Electromagnetic compatibility, EMC, smart city Electromagnetic compatibility - Immunity to conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz - Immunity standard for industrial environments - Emission standard for industrial environments
EN 60068-2-1/2/78/30	Test Cab: Damp heat, steady-state
EN 60255-21-1/2/3	Vibration, shock, bump and seismic tests on measuring relays and protection equipment, Vibration tests (sinusoidal)



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