E3

Transformer monitoring

Monitoring, control and communication for the whole transformer in one modular system

E3

Power transformer monitor

amperis

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Early detection of developing problems raises reliability, cuts maintenance costs and releases the true capacity of the transformer.

Integral transformer monitoring

Where power transformers fail: windings 26 %, OLTC 26 %, bushings 17 %, cooling system 8 %, core 3 %

Why monitor power transformers

On-line condition data generates alarms when problems first arise, so that corrective action is taken before a failure escalates; the built-in analytics filter the data and point maintenance crews straight to the issues that need attention; and the real-time measurement of the operating parameters establishes the dynamic rating of the transformer, releasing capacity that static ratings leave unused.

A modular system engineered to order

The E3 is built to order from DIN-rail modules: the CPU and universal power supply combine with up to twelve digital and analog input/output modules and a multi-port communications module, so the same platform covers from essential thermal monitoring to complete OLTC, bushing and partial discharge supervision.

Monitoring capabilities

- Thermal: top oil, direct fiber winding measurement and insulation aging
- Bushings: power factor, capacitance and partial discharge detection
- OLTC: per-tap counters, contact wear, motor failure, Delta T and breather
- Cooling: fan and pump currents, contactor and breaker failures, efficiency, run hours
- Core, coil and DETC: DGA, moisture and partial discharge
- Oil and conservator: levels, leaks, bladder, breathers and nitrogen pressure
- Through faults: count and magnitude; GIC: neutral DC currents and harmonics
- Renewables impact: harmonics, load profile, power factor and voltage level
- Control system: heaters, auxiliary power, breaker trips, door open and not-in-auto

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Detection and diagnosis

Bushing sensors: insulation health and PD signals

Ruggedized fiber optic winding probe

Partial discharge monitor

The monitor acquires 15 PD channels simultaneously; connected to the bushing capacitance taps it sees far inside the windings, and its noise cancellation distinguishes internal discharges from external interference. Each channel is fully configurable, with two alarm levels in mV or pC; it records pulse magnitudes, pulse counts and full phase-resolved data and stores up to 2 years of history. The sensors — capacitance-tap sensors, RFCTs and Rogowski coils — install externally, and an acoustic PD module can be combined with the electrical monitor.

Bushing health monitor

Up to 12 sensors installed in the capacitance taps measure the capacitance and power factor of each bushing, with three levels of protection including a fail-safe circuit. The sum of the tap currents gives the severity of a defect and its vector indicates which bushing is deteriorating; the system learns the behaviour with load, humidity and temperature during commissioning and alarms on any deviation, and the same sensors also provide the partial discharge signals.

Fiber optic temperature sensing

Fiber optic probes measure the winding hot spot directly: 4 probes per module and up to 3 modules (12 probes), from -30 to +200 °C with an accuracy of ±2 °C or 1 % of full scale and an operating range of -40 to +70 °C. The precise data refine the winding hot-spot model, which can then be copied to the thermal duplicates of the fleet.

Dissolved gases and moisture

Multi-gas DGA analysers and moisture-in-oil sensors integrate through serial links that preserve the digital precision of the readings. All the information is consolidated into one archive, one display and one SCADA file, and a fuzzy-logic model assesses the active moisture in the paper insulation with a traffic-light state and a confidence level.

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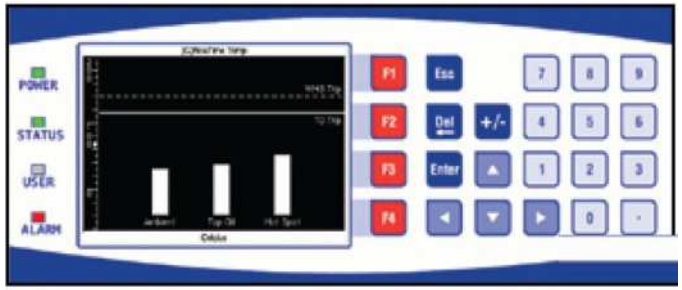
All the information of the transformer on one graphical display, one web server and a single SCADA link.

User interface and communications



Graphical display with status LEDs and full keypad

Optional remote display: folding rack LCD

Local user interface

- Graphical display with historical trends, adjustable font size, status LEDs, full numerical keypad with audible feedback and smart menu keys with eight user-defined favourites.
- Weather-resistant swing-panel mounting; the display operates from -20 to +70 ºC and withstands -40 to +85 ºC.
- Multi-level password management per user group; recommended operator actions with safety warnings and troubleshooting tips.
- Optional remote display for the control room, with no PC operating system; folding LCD version where rack space is limited.

Alarms and data logging

A 1-gigabyte industrial flash card stores data at user-defined intervals — by default one year at 1-minute intervals with up to 200 data points per minute, and up to five years — in CSV format, together with a time-stamped alarm history and configurable event logs; a self-maintained clock synchronised via NTP, DNP or Modbus stamps every record. Alarms are consolidated into common, major and minor sets or unlimited user groups, with diagnostics of occurrences and duration, and a status relay signals loss of power or system failure.

Communications and integration

- Simultaneous master/slave protocols: IEC 61850, DNP 3.0, Modbus and TCP/IP (HTTPS, SFTP, SSH).
- RS-232, RS-485, copper and fiber Ethernet and serial fiber optic ports; radio and powerline communication.
- Pass-thru communication with DGA analysers and other IEDs, consolidated into a single SCADA link.
- Built-in web pages with no software licenses, including a virtual copy of the user display for remote support.

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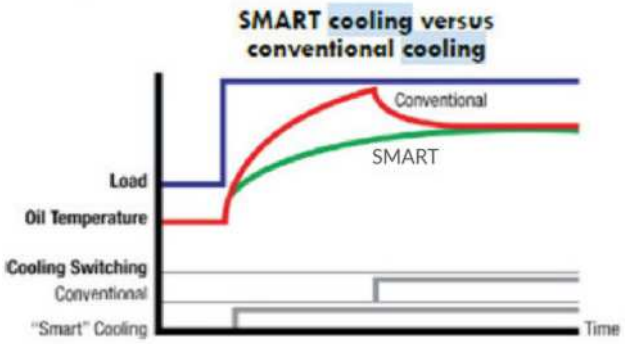
Applications and software



SMART cooling keeps the transformer cooler and reserves overload capacity

Thermal model and dynamic rating

The thermal model to IEC 60076-7 / IEEE C57 adjusts the losses for each tap position and for the health of the cooling system, calculates the hot spot of each winding and accumulates the insulation loss of life. The dynamic rating derives the time remaining and the maximum safe load, and “what-if” calculations answer load-for-time and time-for-load questions; a predictive top-oil model flags cooling problems such as closed radiator valves.

SMART predictive cooling

The cooling control drives more than four discrete stages, dual-speed fans, parallel pumps and variable speed drives, balancing the running hours of each stage. The predictive SMART function starts the coolers ahead of the predicted ultimate oil and winding temperatures, reducing insulation aging and reserving overload capacity; periodic exercising, a low-temperature pump inhibit and “not in auto” alarming complete the function.

Voltage control and OLTC protection

As primary or backup regulator the E3 offers line drop compensation, definite or inverse time delays and paralleling by circulating current, master-follower, VAR sharing or reverse reactance. Voltage, current and circulating-current blockings, the verification of every tap change (positive feedback) and the automatic cleaning of the reversing switch protect the tap changer, while per-tap counters, contact wear, motor energy and Delta T analytics schedule its maintenance.

Web software and fleet visualisation

Every E3 includes web-based software that turns the collected data into an easy-to-understand format, available at any time from a remote location; its dashboard concentrates the critical information needed to judge the health of the transformer. A web fleet visualisation platform aggregates the data of multiple monitors and shows the status and health of every asset, current or historical, at a glance, helping prioritise maintenance decisions across the whole fleet.

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The built-in web pages and the fleet visualisation platform present live data, trends and diagnostics in a graphical format.

Software results and screens

Transformer overview

Built-in web page: live status, gauges, dynamic rating and alarm points

Electrical data and voltage control

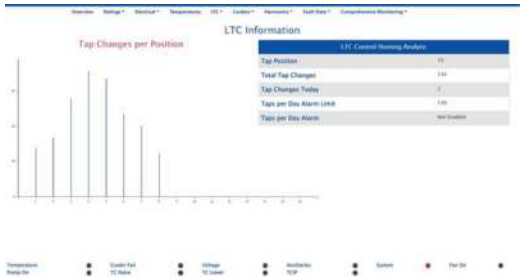
Measured voltages and currents with the voltage-control trend against setpoints

Harmonics and THD

Harmonic content of voltage and current with even/odd total harmonic distortion

Measured and calculated temperatures

Ambient, top oil and winding hot spot with alarm and trip settings



OLTC supervision

Tap changes per position and hunting analytics of the tap changer

Fleet visualisation

Web platform: fleet map with the status and health of each asset

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E3 — MODULES AND OPTIONS

A modular platform built from cards: CPU and power supply plus the input/output and communication modules that each transformer requires.

E3 modules

The CPU and universal power supply modules are mandatory; beyond them the E3 accepts up to twelve modules in any combination — the multi-port module counts as one regardless of the option cards it carries.

CPU + universal power supply (mandatory)	Setup, configuration and file download over USB, copper Ethernet or fiber Ethernet; supply from 48 to 275 V DC or 60 to 275 V AC at 50/60 Hz.
Digital input module	12 isolated inputs per module for alarm contacts, switch or contactor positions; wetting voltages up to 250 V AC/DC; isolation 2.5 kV AC 60 s / 5 kV impulse; status LED per input.
Digital output module	8 form C outputs (NO and NC contacts) for cooling, voltage control or alarms; continuous or pulsed; 6 A @ 250 V AC / 6 A @ 30 V DC; 0.4 A resistive / 0.15 A inductive @ 125 V DC.
Analog input module	6 inputs: 2 AC currents (load, fan or pump), 2 three-wire PT100 RTDs and 2 DC inputs configurable as 0-1 mA, 4-20 mA or 0-10 V DC.
Analog input/output module	The same inputs plus 4-20 mA DC analog outputs driving burdens of up to 400 W, with an accuracy of ±0.2 % of range.
Direct fiber optic temperature module	Fiber optic probes measure the winding hot spot directly; the refined hot-spot model can be copied to the thermal duplicates of the fleet.

Multi-port module options

Any combination of option cards can populate the eight ports of the multi-port module.

OLTC/LTC motor monitoring	Motor current and voltage of the tap changer drive, with alarms on any unexpected deviation.
Dual CT+	Two AC current inputs: transformer load, fan or pump current, fault counting and harmonic content.
Dual PT100 RTDs	Two three-wire RTD inputs: top or bottom oil, ambient, OLTC, main tank or cooler inlet/outlet temperatures.
AC+ input	Measures AC voltage and current and calculates watts and VARs.
RS-232	Connection to a modem or another serial device (EIA-232).
RS-485	Two- or four-wire serial connection to SCADA or other devices (EIA-485).
Serial fiber optic	Serial SCADA connection; multimode 50/100 and 62.5/125 fiber, ST connectors.
DC analog	Two DC signals with ranges of 0-1 mA, 4-20 mA and 0-10 V DC.

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E3 — TECHNICAL SPECIFICATIONS

Architecture	Modular: CPU and power supply plus up to 12 I/O and communication modules; 35 mm (1.37 in) DIN rail; removable numbered terminal blocks
Environment	Operating temperature -40 °C to 80 °C; humidity up to 95 % non-condensing
Power supply	48-275 V DC or 60-265 V AC rms, 47-63 Hz, 50 W; 24 V DC nominal output (18-32 V DC) 0.5 A; IEC 60664 over-voltage category II
Input ratings	Digital inputs 125 V DC/AC; digital outputs 125 V DC / 250 V AC; motor energy 300 V AC; VT inputs 150 V AC; analog and communications 24 V DC (IEC 60664 category I)
Inputs/outputs	12-digital-input and 8-form-C-output modules (6 A @ 250 V AC / 6 A @ 30 V DC); 2.5 kV AC 60 s / 5 kV impulse isolation; analog 0-1 mA, 4-20 mA, 0-10 V DC
Thermal monitoring	Top oil, ambient, main tank, load current, calculated winding hot spot, insulation aging
Bushing monitoring	Up to 12 capacitance-tap sensors (HV and LV); capacitance and power factor; self-learning
Partial discharge	15 simultaneous channels; tap sensors, RFCTs and Rogowski coils; 2 years of data
DGA and moisture	Serial integration of multi-gas analysers and moisture sensors; water-in-paper analytics
Fiber optics	4 probes per module, up to 3 modules (12 probes); -30 to +200 °C; ±2 °C or 1 %
OLTC	Position and per-tap counter, contact wear, motor current, Delta T, hunting detection
Network and events	Harmonics, through-fault counting, geomagnetically induced currents (GIC)
Thermal model	IEC 60076-7 / IEEE C57; dynamic rating: time remaining, maximum safe load, what-if calculations
Cooling control	Predictive SMART; more than 4 stages, dual speed, parallel pumps, VSD; periodic exercising
Voltage control	Primary or backup AVR; paralleling by circulating current, master-follower, VAR sharing and reverse reactance
Communications	IEC 61850, DNP 3.0, Modbus, TCP/IP; RS-232, RS-485, copper/fiber Ethernet, serial fiber, radio, powerline
Data logging	1-minute intervals with up to 200 data points; up to 5 years; 1 GB non-volatile; CSV export
Alarms	Common, major and minor groups; time-stamped log; occurrence and duration diagnostics
Interface	Graphical display, status LEDs, numerical keypad, weather-resistant swing panel; built-in web (HTTPS)

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