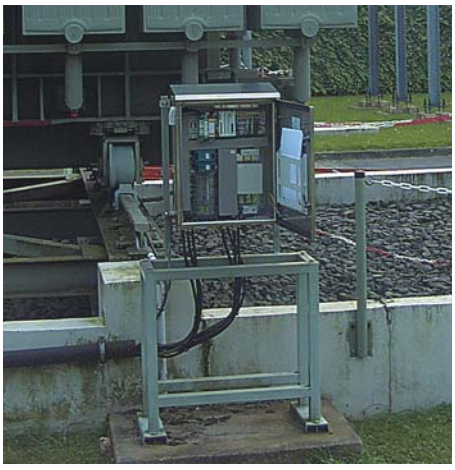
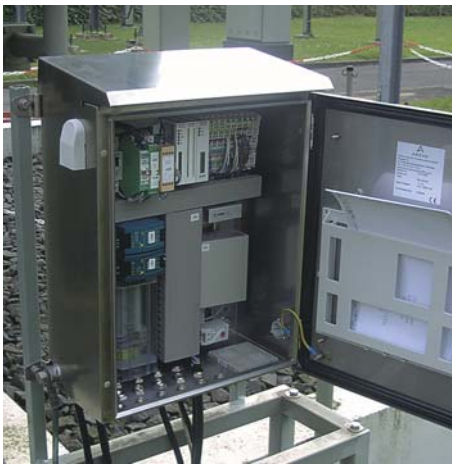
PC-Control 01|2007

Online-monitoring for power transformers

PC control under high voltage

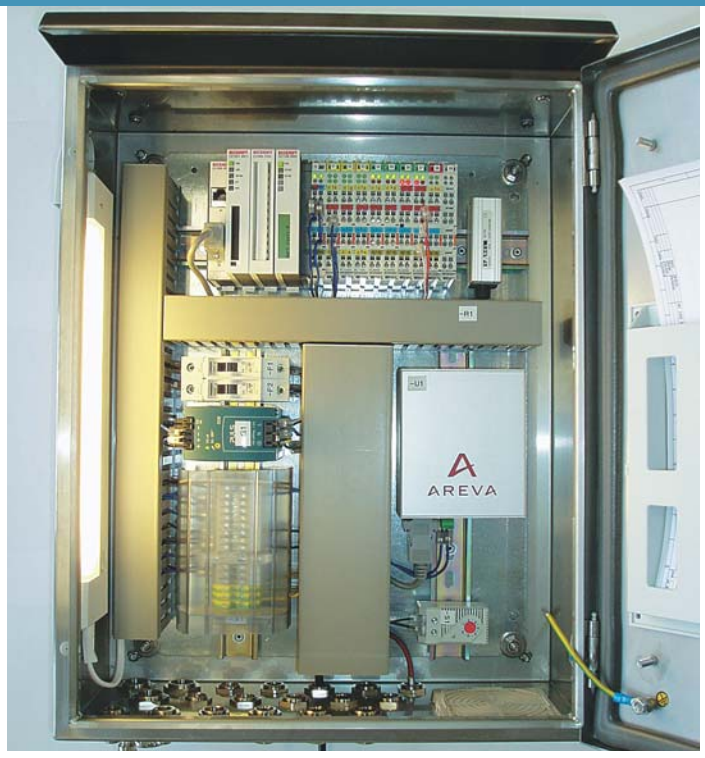




The online monitoring systems from Areva T&D provide precise information about the operating state of power transformers and are the basis for increased availability, cost optimization through condition-based servicing, and avoidance of faults and downtime. The control platform of the new MS 2000 Basic and MS 2000 Bushing monitoring systems is based on Beckhoff Embedded PCs with high computing power, integrated software PLC, modular I/O components and local data acquisition with a sampling rate of 100 kHz.

Established in 2001, Areva Transmission&Distribution (T&D) is part of the Areva Group, which is a leading international Group for energy production and distribution with 58,000 staff in more than 100 countries. As a global company for development and production of power generation products, Areva T&D supplies, among other things, power transformers for a variety of applications – ranging from installations with small rated power to the highest available rated power with voltages of up to 800 kV. These power transformers can be used in any power plant around the world, be it thermal, conventional, combined, nuclear, hydro power plants or wind turbines. In addition to conventional power transformers for energy transmission, generation and distribution, the company also develops and produces special transformers such as high-voltage DC inverters, traction, earthing, reactor or rectifier transformers.

Power transformers are the nodes of all power grids. The quality and stability of the grids are a highly dependent on the reliability and availability of the transformers. Continuous status monitoring and diagnosis is useful and indeed required for optimizing operational management and reducing maintenance requirements.



Beckhoff Embedded PC in the MS 2000 Basic monitoring system

Technical data/topology
MS 2000 Basic I/O modules
8 analog inputs with a logging rate of up to
5 ms (e.g.: 0/4...20 mA, PT100 RTD)
12 digital inputs and up to 4 digital outputs
(e.g.: relay contacts up to 230 V AC/30 V DC)
MS 2000 Bushing I/O modules
(add-on for MS 2000 Basic)
9 analog inputs (oscilloscope terminals)
with a logging rate of up to 10 µs (e.g.: ±10 V)
3 digital outputs (trigger outputs)
CPU module
CX1000 Embedded PC, Pentium MMX 266 MHz,
PC/104 standard, real-time clock
16 MB flash memory, 32 MB RAM
256 MB additional flash memory
(exchangeable)
Interfaces: serial (RS232) or
modem (fax); TCP/IP (RJ 45)

High-performance measurement technology

The MS 2000 Basic module from Areva T&D records the analog inputs for load current, voltage and the tap change process as well as the upper oil and ambient temperature with a logging rate of up to 5 ms. These parameters can be used to calculate additional values such as hotspot temperature, ageing rate, power and load factor. Further optional analog inputs such as gas-in-oil content, oil moisture content or additional temperatures, etc. can be integrated in the analysis. The measurement readings are recorded via analog fieldbus terminals that are directly adapted to the CX1000 DIN rail PC via the integrated interface.

The MS 2000 Bushing module was specially developed for monitoring high-voltage bushings in transformers. This measurement is crucial for assessing the operational status, because undetected defective bushings can lead to the destruction of the whole transformer. In the past the required measurements (bushing capacitance C and loss factor tan δ) were often carried out offline. To this end the transformers had to be disconnected from the grid network and the high-voltage lines had to be removed from the bushings, which meant significant cost and effort. Thanks to advanced fieldbus technology and the application of fast oscilloscope terminals from Beckhoff, the measurements can now be carried out online with the aid of a monitoring system.

Measurement of the phase angle between the three phases enables changes in the dielectric loss factor tan δ to be detected. The challenge for the instrumentation is to detect very small changes. For example, a change in loss factor tan δ by 0.1% corresponds to a change in phase angle of 0.057 °.

The oscilloscope terminal, which is integrated into the Beckhoff Bus Terminal system (just like a terminal for analog value logging), records data with a sampling interval of 10 µs (100 kHz) in order to detect zero crossing of the 50/60 Hz AC voltage. The measurement readings (up to 32,000) are initially stored locally in the terminal and then cyclically read by the CPU. The high computing power of the PC-based control system enables direct processing and analysis of the data. The analysis algorithm interpolates the measurement readings based on a cross-correlation function in order to optimize precision.

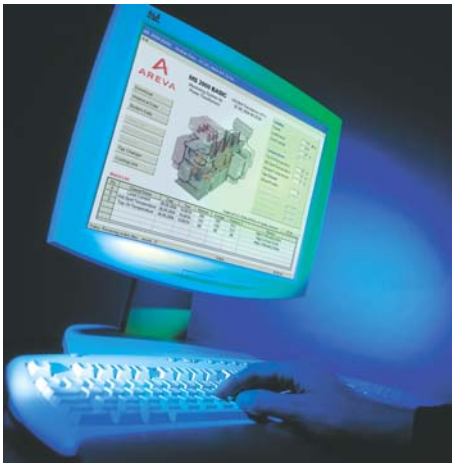
Δtan δ must be recorded with a minimum precision of 0.15%, because the loss factor for the different bushing types is around 0.5% and a maximum warning threshold of approx. 0.7% should be assumed. A precision of 0.03% can be achieved with the solution described above.

Optimized archiving

The Embedded PC is installed as an independent system directly at the transformer. It is fanless, has no hard disk and is therefore robust with low maintenance requirements. An industrial Compact Flash (CF) card is used as storage medium for the operating system and data. Intelligent memory management ensures that each memory location is written in a statistically uniform manner, resulting in optimum lifetime of the CF card. The archiving period for historic data (or the saving interval) can be configured via the storage capacity. In the current configuration with a 1 GB CF card, current datasets are stored every 15 minutes and archived, exemplary for this configuration, for 5 years.

User-friendly, flexible configuration

In conjunction, the PC and the Bus Terminals form a modular system that can be adapted individually to the application. Configuration modules that are optimized for the application were developed with the aid of TwinCAT software in order to ensure simple and fast installation and commissioning. Naturally, this approach



Customer benefits through online monitoring systems

- Enhanced transformer availability
- Precise information about the operational status of transformer bushings
- Cost optimization through condition-based servicing
- Avoidance of faults, downtime and collateral damage
- Extension of residual lifetime
- Enhanced energy transmission through optimized overload capacity

also offers benefits for servicing. For example, an auto-configuration mode is available for the hardware. Each active terminal is automatically provided with the required parameter settings, which means that

- Analog channels are parameterized in terms of filter times, characteristic linearization curves, measuring range and sensor types.
- For oscilloscope terminals, the sampling rate, buffer size and trigger type are set.

Simple parameterization or scaling options are available for data archiving:

- Archiving interval
- Selection of assessment and weighting criteria for the measurement readings

Remote maintenance and visualization included

Windows CE is used as operating system on the Embedded PC. The integrated communication interfaces can be used for efficient remote access. A distinction is made between two operating modes, i.e. remote PLC maintenance and data transfer for visualization and sending of fax messages in the event of an alarm.

TwinCAT offers a variety of remote maintenance options for the PLC and system programs, ranging from pure monitoring of PLC variables to online modification of the running program. In addition, the current operational status of the transformer can be monitored. Another important feature is sending of error messages by fax in order to alert the responsible service staff. Remote access enables a locally installed fax modem that communicates with the Embedded PC via the serial interface. Switchover between operating modes is realized in a programmer-friendly manner with a .NET program on the Embedded PC.

Visualization is demand-oriented and based on a Visual Basic program. The visualization computer accesses the Embedded PC remotely via the modem and communicates with the control system and measuring programs via the OCX interface integrated in TwinCAT or loads historic measured data from the CF card for analysis. The saving interval is freely selectable.

High-performance, future-proof monitoring system through PC control

The demands placed by monitoring systems on the system platform are ideally met by the CX1000 Embedded PC with Microsoft Embedded operating system, modular Bus Terminals and TwinCAT software. Due to its high processor power and the integrated hardware FPU (Floating Point Unit) the PC CPU is able to carry out complex calculations, e.g. with real numbers (cross-correlation). At the same time a wide range of analog channels are monitored with short cycle times via the integrated software PLC. Intelligent Bus Terminals with a sampling rate of 100 kHz, such as the oscilloscope terminal, form the basis for new functionalities. In addition, the platform used offers high investment security. The complete software was developed with standard tools (IEC 61131-3 for data logging and analysis, and .NET and Visual Basic for the interface and system programs) and is therefore "future-proof applicable" or can be simply ported to platforms, if required. The hardware basis also offers plenty of reserve capacity.

⟶ Areva T&D **www.areva-td.com**