Getting the most out of electrical equipment is vital to energy enterprises in today’s increasingly deregulated world. With power transformers making up a substantial part of that equipment, it is little wonder that utilities put a premium on enhancing the lifetime and performance of these industry workhorses.

Conventional control and monitoring schemes rely on past results – good enough, perhaps, for routine maintenance and non-critical units, but not to keep transformers performing constantly, and unfailingly, at the highest level. Not so ABB’s Transformer Electronic Control (TEC) system. This models the actual state of the transformer, creating a ‘virtual copy’ that provides the parameters required to optimize cooling as well as the data utilities need for condition-based maintenance.

Power transformers at critical nodes in electricity networks lead stressful lives. Reliability is everything. Load peaks – predictable as well as unexpected – generate high temperatures, which shorten component lifetime. In the worst case, sudden failure can occur, causing havoc in the network. It is because of this risk, and the penalties that can attach to it, that utilities give such a high priority to controlling and monitoring the status and con-
dition of their transformers. This lets them intervene before failure or malfunctioning can occur. Increasingly, for many utilities, the watchword is ‘early detection of failure conditions’.

**Enter the ‘intelligent transformer’**

Deregulation of the energy markets has brought about a paradigm shift and focused attention on, among other things, ‘asset management’ and ‘remaining life management’. As a result, an increasing number of power transformers around the world are being equipped with monitoring devices. As this trend intensifies and more and more functionality is added, transformers are likely to play a new role – as ‘intelligent units’ – in future transmission networks.

The trouble with many transformer monitoring systems is that they are not able to control or make decisions and recommendations based on the available data, forcing engineers to spend a lot of time sorting and interpreting the information they receive. This is the strength of Transformer Electronic Control (TEC). TEC receives all the information it needs for transformer control from just a few multi-purpose sensors; other necessary parameters are calculated. Thus, TEC adds only minimal complexity to the transformer.

To achieve the goal of making power transformers ‘intelligent’ and maintenance-free, ABB created and integrated a common electronic interface that exchanges information with the following apparatus:

- Monitoring and diagnostics devices of the transformer and components
- Transformer control cabinet
- Tap-changer motor-drive
- Voltage regulation system
- Overall protection system

Through this interface, TEC provides exact status information to enable utilities to extend transformer lifetime and save costs by reducing maintenance and increasing availability.

It does this by generating a model of the transformer and its working condition and then comparing the measured parameters with the simulated values. Discrepancies are detected and potential malfunctions and/or normal wear in the transformer and its ancillaries are indicated.

As ABB’s fully integrated control and monitoring solution making use of one original set of multi-purpose sensors and employing specific transformer design data, TEC is the latest addition to a product portfolio that already includes the ABB T-Monitor. The T-Monitor is a proven retrofit solution that provides adequate predictive power by means of easily fitted add-on sensors and models that require less detailed information about the transformer and its component design.
**TEC architecture**

The system hardware and software features prove ABB technology and has been designed to allow extra functionality to be added in the future. Being microprocessor-based, the system has more flexibility than a PLC and provides a more stable platform than a PC solution.

TEC gets its capability to control and monitor not only from its superior software, but also from the fact that it has unlimited access to all the information it requires. It knows everything about your transformer. This ‘knowledge’ begins with the transformer design data. Next, temperatures and loss-related parameters obtained from the transformer heat-run test are fed in. So much data is transferred to the TEC system that it becomes a ‘virtual transformer copy’. Each transformer has its own ‘fingerprint’, with all the parameters needed for optimized control. The model created by TEC works in simulated conditions but reacts in the same way that a real transformer would.

The main parameters are processed in the TEC cabinet and transferred to the station PC via a single optic fiber. They are made available to the operator via easy-to-use software and a display.

**TEC and Industrial IT**

Industrial IT [1] has been introduced by ABB as an architecture for seamlessly interconnecting all our Group’s products, solutions and processes. More than that, it allows our customers, service partners and third parties to connect with them too. Industrial IT enables the total integration of business processes with real-time and lifetime data management. As a consequence, utilities will be able to substantially improve the efficiency of their business.

Utility assets, such as power transformers, are prime candidates for such real-time integration. And TEC is an ideal means of integrating them. It is certified to Level 2 (Integration), which means that it is not only information enabled and can be connected to and will work well in an Industrial IT system, but also is able to exchange extended data, like status and maintenance data, via defined protocols. Systems with Industrial IT Enabled components offer a variety of advantages, including ‘plug and produce’ capability. Disturbances are reduced at the same time that flexibility is increased.

**Feature overview**

TEC offers a whole range of functions designed to let utilities use their transformers to the maximum. Until now, service criteria have been based on load assumptions and the results of the last service. TEC changes all this. Real-time information opens up new possibilities for optimizing operation and maintenance.

**Cooling/overload forecast**

Traditionally, transformer cooling is a two-step system, with the option of 50% or 100% capacity. With TEC, six steps are possible, according to load, ambient conditions and cooler status. The coolers are controlled individually and can be started prior to an anticipated load increase. This reduces thermal stress and adds hours of operation at maximum capacity.

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*Industrial IT enables the total integration of business processes with real-time and lifetime data management. As a consequence, utilities will be able to substantially improve the efficiency of their business.*
TEC advanced cooling control is based on algorithms that calculate the heat losses and the number of coolers required to dissipate them. It also keeps track of the number of hours each fan is in operation and runs all motors accordingly. As input, TEC receives data on the actual and/or predicted load and ambient conditions. Armed with this information, the system is able to respond immediately to load peaks, and the cooling capacity can be better adapted to actual demand. Further, it can simulate the results for a specific load condition or forecast the maximum overload duration based on the hot-spot results.

**Real-time status/availability**

The parameters measured during service are compared with the simulated values. The transformer model detects discrepancies and indicates potential malfunctions and/or normal wear in the transformer itself, the cooling equipment and the tap-changer.

Real-time information from temperature sensors and from optional moisture sensors is stored by the TEC system. If required, a hydrogen detector can be mounted on the tank to obtain an early indication of potential problems in a transformer winding.

A rolling LCD on the front panel shows the main parameters together with a three-lamp status ‘traffic light’
By giving utilities the means to monitor, and thereby optimize, the way they operate their power transformers, TEC can be said to be truly transforming transforming.

(green/yellow/red). The same information can be viewed on a PC terminal, either in the substation control room or at a remote location ②.

**Lifetime**
Temperature control, based on overload forecasting and winding hot-spot calculations, allows the consumed lifetime to be computed in accordance with the latest IEC and IEEE standards.

**Event recording**
TEC also keeps track of transformer trips and alarms, recording the actual events as well as the sequence to assist operators in determining their root cause.

**Condition-based maintenance**
The status traffic light identifies the most heavily worn contact in the tap-changer, based on the actual load during each operation. The user sees when the next service is due.

Oil treatment is condition-based, being dependent on the development of moisture as indicated by the temperature and (optional) moisture sensor in the tap-changer compartment. Early warning is given of any increase in tap-changer temperature beyond the normal value.

**Operation and updates**
The user interface runs in the Windows environment. The PC start panel ③ shows a transformer model with basic data such as the top-oil and bottom-oil temperatures, up to three hot-spot temperatures, the apparent power and the tap-changer position and operations. More detailed information can be obtained by clicking on the object on the transformer model or by pressing one of the status information buttons.

All of the transformer and tap-changer documentation, including instruction films, can be viewed on the PC in the control room or any other place of convenience ④.

**Tried and proven**
Environmental tests, hardware/software functional tests and on-site tests in various parts of the world have shown that the system is well suited for substation environments.

ABB’s extensive experience with electronic equipment in harsh industrial environments has also been incorporated in the design of the TEC ⑤. For example, it is EMC compliant and vibration proof.

**A modular system**
TEC is the first of a generation, and ABB continues to investigate new approaches and ways to improve the system as a whole and in part. Further parameters for the transformer, tap-changer and bushings will be included in the future. TEC’s modular design makes this easy, and provides the flexibility that will ensure its success as an innovative and cost-saving product. By giving utilities the means to monitor, and thereby optimize, the way they operate their power transformers, TEC can be said to be truly transforming transforming.

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**Reference**

A detailed overview of TEC.

Technical Specifications.

**Power supply:**
Universal 85-265 VAC, 50/60 Hz, and 85–265 VDC. It is recommended to connect both AC as main supply and DC from station battery as spare supply. TEC will automatically switch without interruption in case of outage on any of them.

**Front panel:**
- Push button to start up the LCD display
- Rolling LCD display showing top-oil temperature, up to three hot-spot temperatures, bottom oil temperature, apparent power, Tap-changer position, Tap-changer operations, hydrogen content (if applicable). Temperatures are displayed in both degree Celsius and Fahrenheit.
- Status traffic light with three lamps (green/yellow/red).

**Environmental:**
- Operating temperature -40 to +50°C (-40 to 122°F).
- Degree of protection IP 56, according to IEC 60529
- Temperature cycling tested -40 to +70°C, 90% humidity
- Dimensions (mm): Width 500, Height 600, Depth 300
- Weight approx. 25 kg
- EMC compliance
- Vibration tested

**Input Parameters:**
- 8 insulated analogy 4-20 mA via terminals, for current transformers, sensors etc.
- 4 insulated Pt100 direct inputs, for temperature sensors.
- 12 insulated digital input via terminals, for fan motor status, alarm / trip signals etc.
  Mouse signals can be added on request.

**Output Parameters:**
- 3 outputs for alarm, warming and trip signals.
- Tap-changer raise / lower

**Fibre Optic Cable**
The connection between the TEC and the station computer is made via a fibre optic cable.

**Station Computer**
- Processor > 800 MHz, 256 Mbyte RAM and 5 GB available hard disc space
- Operating system: Windows 2000 or higher
- Fibre optic to serial converter
- For remote access of the PC a modem or broad band connection is needed