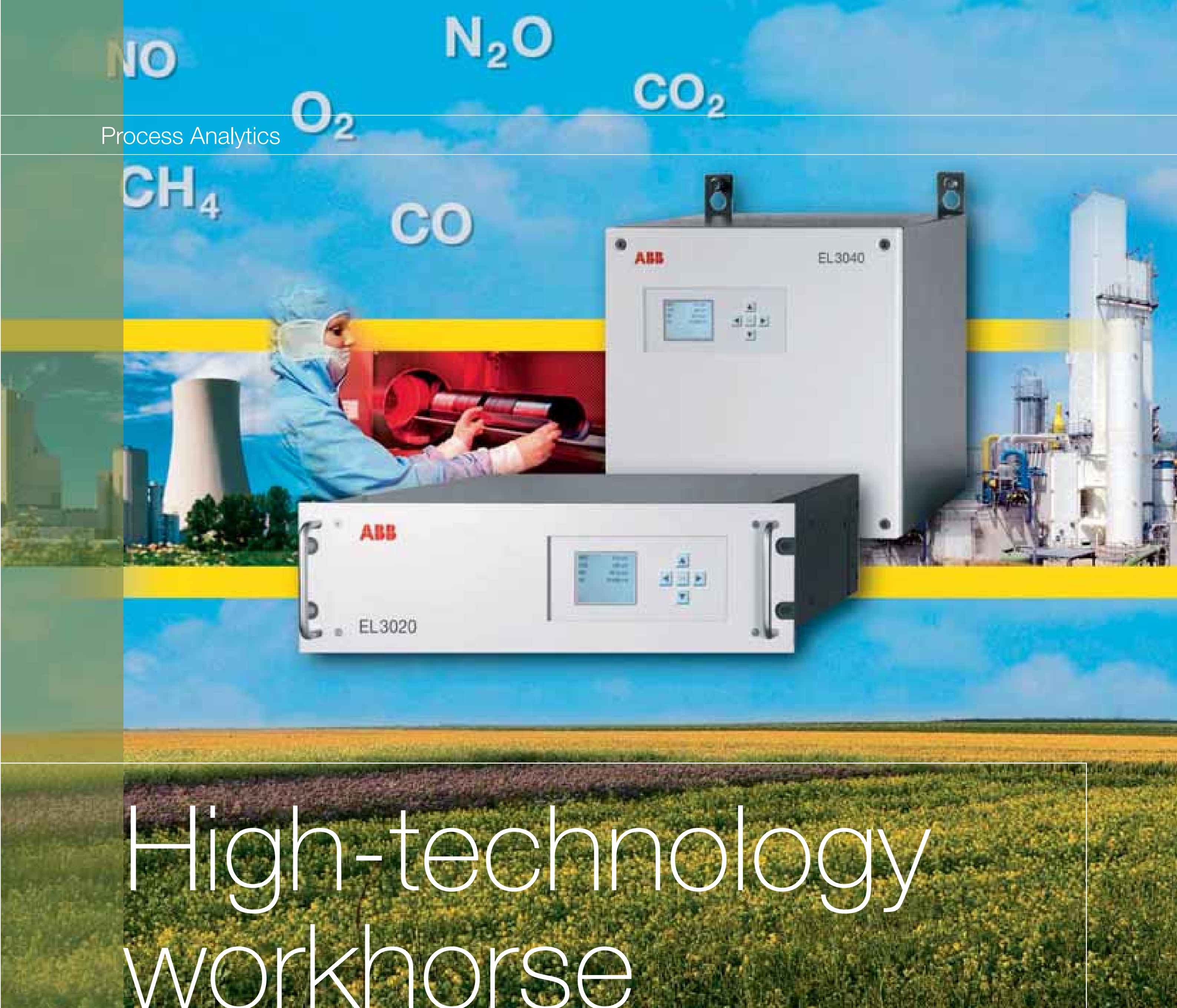


High-technology workhorse

Advancing contemporary modular gas analyzer technology with the Uras26 photometer

Werner Rüdiger, Carsten Rathke, Michael Ohland, Mario Crevatin

Worldwide environmental awareness and tightening industry regulations are leading to tougher emissions standards. These in turn are calling for greater accuracy in measurement technology. At the same time, the drive for greater productivity in industrial processes means that single installed devices must be able to monitor as many different gas components as possible as accurately as possible while minimizing down-time and human intervention through auto-calibration functions and intelligent filtering of data-output. Ideally, such a device should be built on a flexible platform, facilitating future upgrades and the integration of new functions, and so protecting the customer's investment.

ABB's continuous gas analyzer module like Uras26 uses high performance measurement technology and has the ability to quantify ultra-low concentrations of gas. It can simultaneously monitor four different gases. The advanced algorithms running on its digital signal processor eliminate much of the guesswork and imprecision that is associated with traditional instruments – while additionally assuring these algorithms can easily be upgraded to meet future needs.

Environmental protection, process optimization, quality assurance and cost reduction are key issues for processing industries today. Owing to their flexibility, gas analyzers are used in a wide range of measuring tasks in almost every industrial process: in chemical and pharmaceutical production, in gas production, in the processing of metals, minerals, paper and wood pulp, in power generation and in environmental applications.

Contemporary modular analyzer technology introduces state-of-the-art module electronics, intelligent algorithms and continuously improved measuring physics. ABB offers two different product lines, Advance Optima and EasyLine, both of which are highly flexible and provide optimum results at low cost. The Advance Optima product line is based on an integrated system design. It permits multi-analyzer and complete analyzer systems to be set up cost-effectively. The EasyLine product range is distinguished by simple gas analyzers of reliable design.

Spurred by the need for standardization and simplification of the control of gas analyzers, a new electronic "Common Platform" that forms the innovative core of the module, was developed.

The common platform

The common platform provides a standard interface for all analyzer types, thereby overcoming the considerable functional differences between measurement techniques, from the measurement of a Wheatstone bridge voltage to measurement through complex modules, such as a photometer. At the beginning of the development phase, it was, therefore, necessary to identify what all analyzers have in common and to model these shared characteristics in hardware and software.

All analyzer types are characterized by the fact that they use a complex method to convert a physical effect into an electrical signal – this was therefore taken as the underlying principle on which further investigation and validation rested.

A raw digital measured value is generated from the analog electrical signal in an analyzer-specific electronic system. If the common interface is now programmed for the transmission of this raw measured value, a standard analog/digital converter is created for all analyzer types. The raw signals can then be further processed by means of a common hardware and software platform (common controller), which is virtually independent of the measurement technique 1. At this stage, the raw measured value is scaled, linearized, pressure or temperature corrected, filtered – or "refined" by some other means.

A serial hardware interface was selected, which besides transmitting data to the analyzers, also integrates the 24 V DC power supply. All other required voltages are generated in the modules. Besides the performance requirements, an important criterion for the serial interface was that it can be supported from the simplest controllers to high-grade signal processors.

The software model is also characterized by the greatest possible compatibility with all analyzer types. The analyzer model was developed from a detailed analysis of all requirements. All analyzer data and functions were mapped in software components – a "virtual analyzer" covering all different analyzer functionalities was developed.

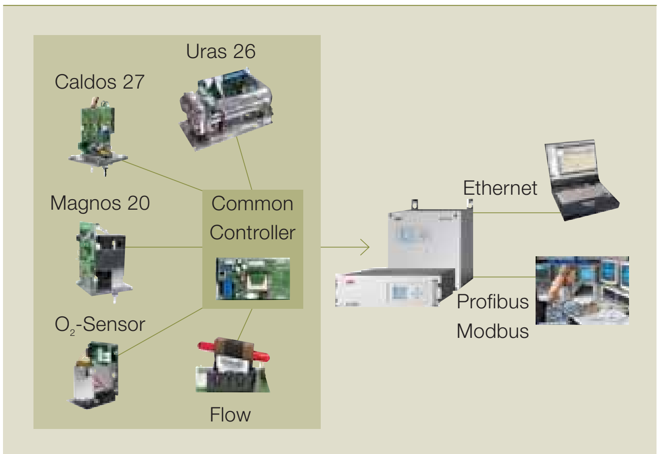
Basically, an analyzer consists of 1...n detectors (thermal conductivity, infrared etc.), each detector measuring 1...n components (CO, CO_2 and so on) and each component having 1...n measuring ranges. If this data is modeled and combined with modular signal processing and corresponding correction functions, a virtual analyzer, suitable for most analyzer functionalities, is obtained.

The common platform affords many advantages, such as reduced integration time for new measurement techniques, reusable hardware and software components and the common use of external interfaces such as Ethernet, PROFIBUS, Foundation Fieldbus digital and analog Input-Output (I/Os). In addition, the same software tools can be used for all instruments. The end result is a higher degree of production automation achieving further process simplification.

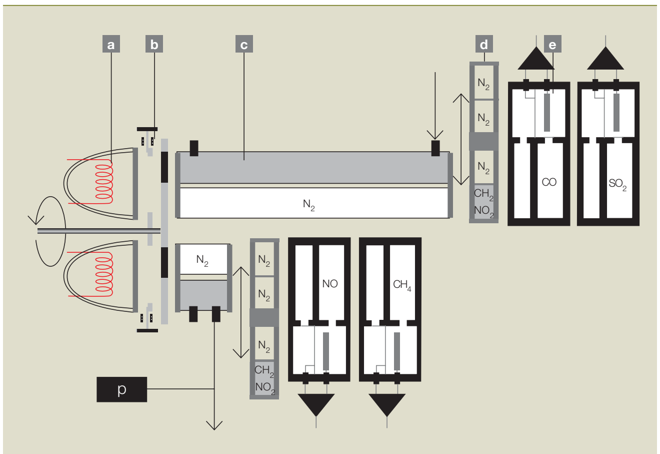
The Uras26 Gas Analyzer Module

In connection with the launch of the new common platform, an ABB front-runner was upgraded: the Non-Dispersive Infrared (NDIR) Uras photometer. The tried-and-tested optical construction of the Uras14 2 was com-

1 Overview of Common Platform-compatible modules of the new EasyLine product range



2 Schematic representation of the optical structure of the Uras. a Infrared lamp, b Chopper wheel, c Sample cell, d Calibration cell, e Opto-pneumatic detector



bined with the new Sensor Specific Interface (SSI) modular electronics, making it compatible to the "common platform" technology.

The measurement principle of the Uras is based on the capability of gas molecules to specifically absorb infrared (IR) radiation. This means that energy is removed from a light beam within a certain frequency range, depending on the gas concentration. In most infrared gas analyzers a photo detector is used to detect this effect. This is not the case with the Uras: It contains gas-filled, so-called "opto-pneumatic" detectors, in which the sample of interest is held. The radiant energy absorbed by the fill gas causes a change in temperature and thereby a change in pressure in the detector. This change in pressure evokes an electrical signal via a membrane capacitor. The correlation between the detector gas and the sample gas provides an extremely high selective sensitivity with regard to gases such as CO, CO_2, SO_2, NO, CH_4 and N_2O – to name but a few.

The measurement principle of the Uras is based on the capability of gas molecules to specifically absorb infrared radiation.

In the Uras26, the concentrations of up to four process gas components can be reliably determined by connecting detectors in series. The length of the sample cells installed upstream of the detectors determines the provable concentrations, which range from a few parts per billion by volume (ppbv, <10^{-5}% Vol.) to 100% Vol. The Uras26 also has integrated calibration cells, which automatically move into the optical beam path [1]. These supply a reference signal and ensure long-term stability. Maintenance costs are markedly reduced because built-in calibration dispenses with the need for expensive test gas cylinders.

A low-noise measurement is provided by periodic modulation of the IR radiation source with an interrupter disk ("chopper wheel") and subsequent frequency – and phase -selective amplification. This type of signal processing is generally referred to as a "lock-in" process [2]. Up to four Application Specific Integrated Circuits (ASICs) were used for calculating the amplified lock-in signal in the previous model, Uras14. The development of a "digital" lock-in amplifier for the Uras, with extended functionality, was also undertaken during the development of the new Common Platform-compatible module electronics.

The development stages

Development of the module electronics for the Uras26 was carried out in three phases. In the first phase, the existing preamplifier was extended from a purely analog principle to an independent hardware unit with a digital interface. On the basis of this preamplifier and its compatibility with the existing sensor, digital measurement values could be acquired very quickly and made available for further evaluation.

In the second phase, new algorithms for the "lock-in signal" were tested 3 .

In parallel the hardware, which had so far been based on an ASIC, was reworked. A flexible and high-performance Digital Signal Processor (DSP) enabled a far more accurate phase correction, a higher dynamic range of the "lock-in signal", a more accurate monitoring of the motor speed, as well as the implementation of new instrument functionalities. The modulator, which includes the motor, the chopper wheel, a light barrier, as well as the infrared lamp, was simplified at the same time 4 .

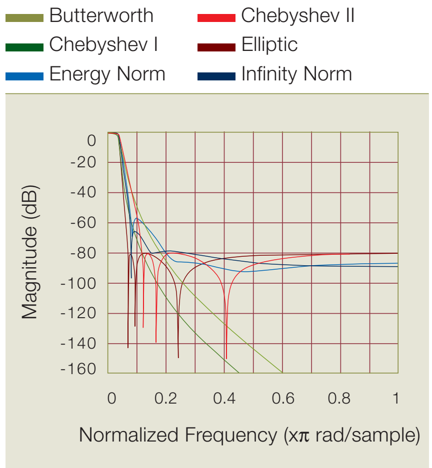
An overall simulation of the instrument enabled further verification of the solutions found, and tested the behavior of the instrument for a future extension of functions. The physical generation of the signal within the sensor is a fitting example 5 .

In the third phase, new algorithms were tested on the developed Uras26 unit with a view to offering further instrument functionalities for low-maintenance operation and reasonably priced service in future.

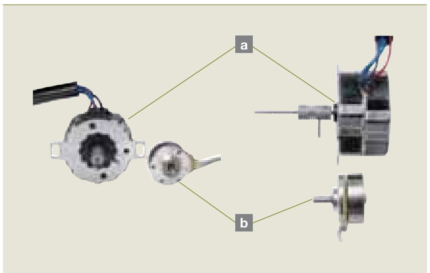
New potential with the use of DSP

Improving or adding new features in an ASIC based system involved redesign of the ASIC and the rest of the hardware – a very expensive and time-consuming proposition. An important advantage of replacing ASICs with DSP is that integration of future functionality and performance improvements can be achieved without

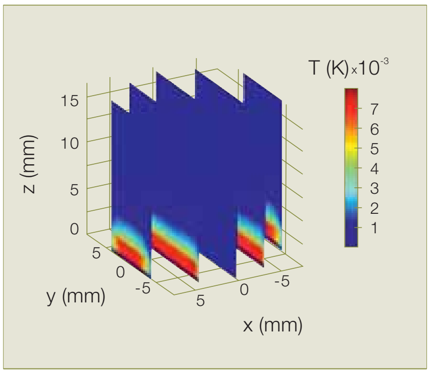
3 Frequency responses of various new signal processing algorithm



4 Size comparison of the old motor a and the new motor b of the Uras modulator



5 Physical signal generation (temperature change) at various locations in the Uras detector; red for strong, blue for weak changes



altering the hardware design. For instance, extended diagnostic features of analyzer components for the purposes of "remote maintenance" or "predictive maintenance", and the new intelligent shock suppression are of particular value to the customer.

The shock sensitivity of the sensor results from its high measurement accuracy. Its acute sensitivity to the lowest gas concentrations also makes it sensitive to other influences, such as temperature changes or shocks. To reliably detect shocks, a clear distinction must be possible between signal changes caused by modifications in the gas concentration, and signal changes caused by shock. The DSP achieves this by looking at both the digital measured values over time, and their frequency components – with and without shock.

When a shock is reliably detected, it is necessary to correct its influence on the actual measurement signal. The DSP carries out this calculation in real-time. Taking a series of shocks as an example, 6 illustrates their suppression.

Uras26 is an advanced system that eliminates much of the practice and guesswork associated with conventional instruments.

Key Benefits

Thanks to its DSP-based electronics, the Uras26 analyzer module offers extended signal analysis capabilities, such as signal filtering, diagnostic functions and cross-sensitivity optimization. The most notable benefits of the Uras26 – placing it ahead of the field – are: its ability to simultaneously analyze four gases and its integrated calibration cells that significantly reduce downtime. Uras26 is an advanced system that eliminates much of the practice and guesswork associated with conventional instruments.

As a result of the measurement performance and high stability, EasyLine analyzers can be used for emission monitoring according to the new European Directive 2001/80/EC.

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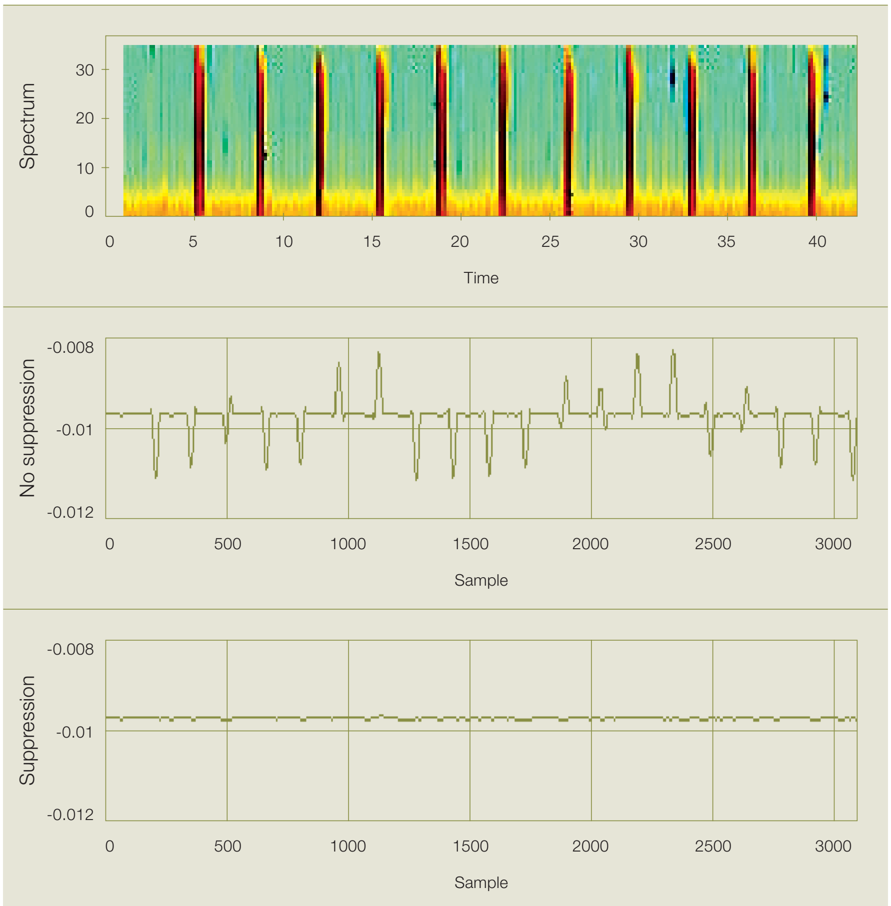
6 Digital measured values; Top, broken down into the frequency components (red = strong, blue = weak frequency components) – Center, without shock suppression – Bottom, with shock suppression



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