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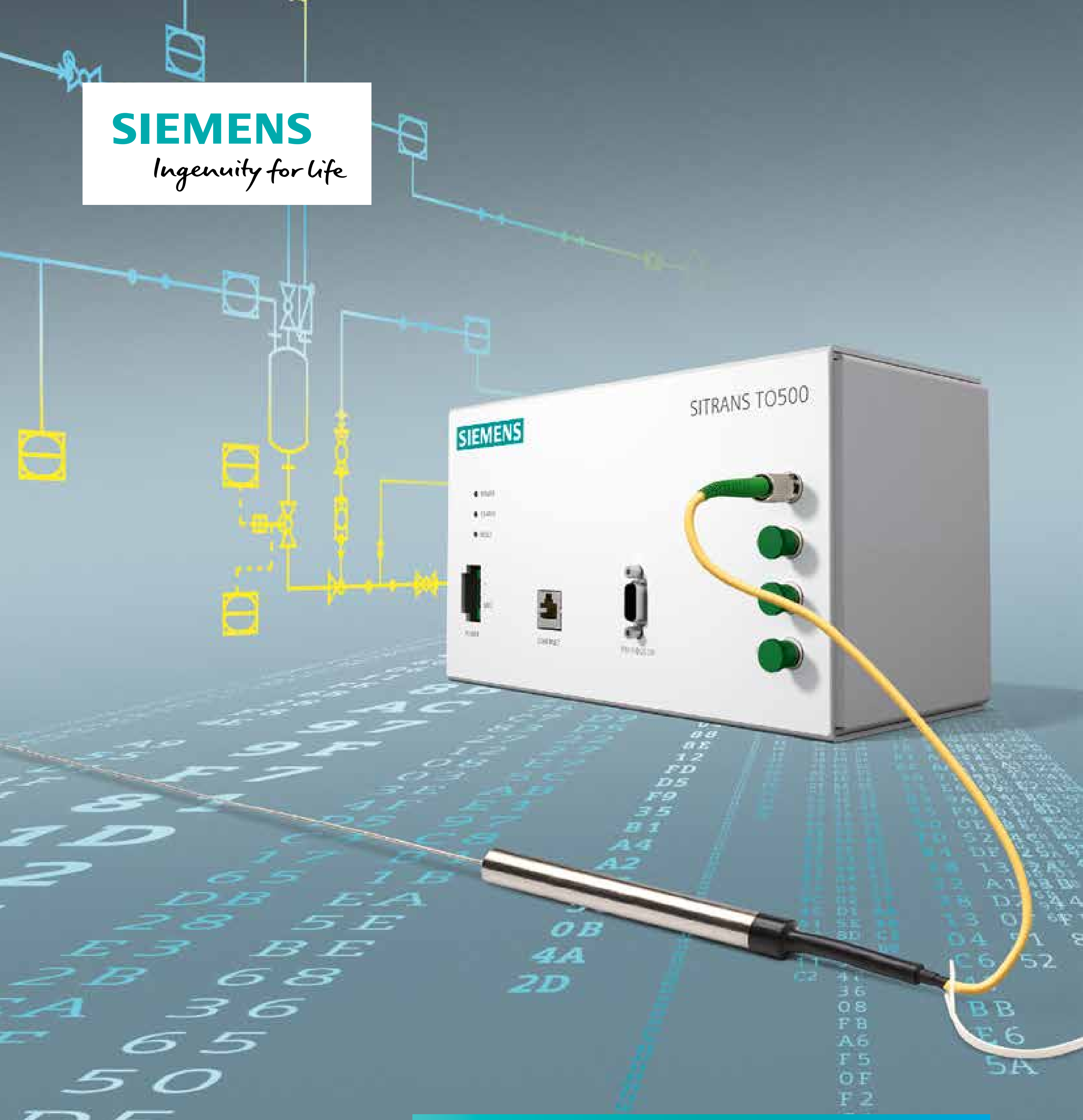


SITRANS TO500

The fiber-optic sensor – measuring what used to be impossible.

usa.siemens.com/TO500

SITRANS TO500

The extremely thin multipoint measuring system

Measured values are transmitted through an extremely thin sensor measuring lance. The diameter of the sensor measuring lance is independent of the number of measuring points.

Optimize the life cyle and yield

Recognizing temperature profiles and detailed understanding of the process are great challenges to plant operators. The fiber-optic based SITRANS TO500 multipoint measuring system enables you to determine a large number of temperature measuring points along a single sensor fiber and read out a temperature profile in a matter of seconds. For example, you can quickly and precisely identify points overheating to help avoid or counteract potential damage to your product and/or equipment.

Typical application areas for the SITRANS TO500 are temperature measurements in:

- Tube and tube-bundle reactors
- Capillary and microreactors
- Distillation
- Rectifications

Function of the SITRANS TO500

Do you want to install a very large number of measuring points in the smallest possible space with a low thermal mass? The fiber optic weighs only a few gram, and its diameter of < 2 mm enables the SITRANS TO500 to make measurements in very narrow protective tubes, because the larger cross-section provides a larger volume for the reaction in the reactor.

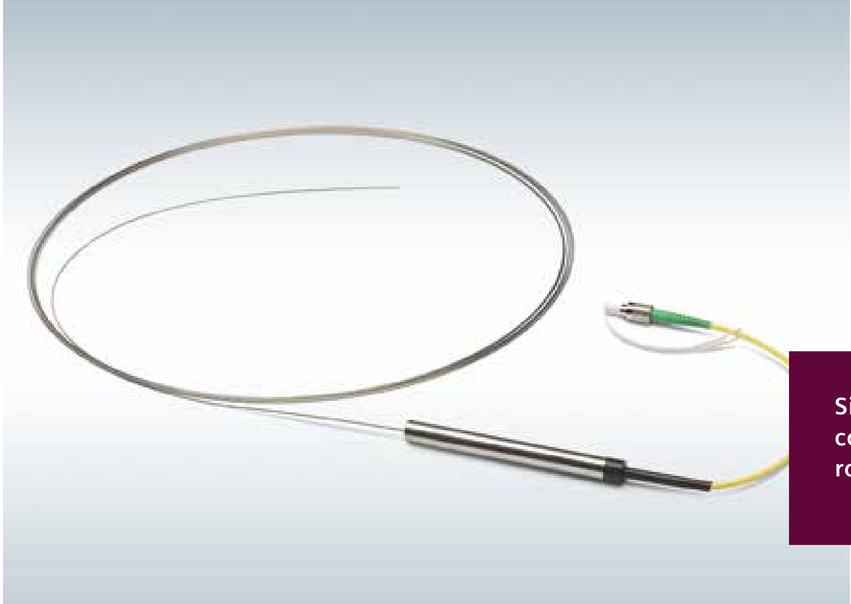
The response times of the sensors are also reduced because of the low thermal mass of the fiber optic.

The SITRANS TO500 multipoint measuring system comprises two components:

- Transmitter (reading unit)
- Sensor measuring lances (with up to 48 temperature measuring points)

A continuously tunable laser generates light in the SITRANS TO500 transmitter with a wavelength between 1500 and 1600 nm, which is output to the sensor measuring lances. The transmitter evaluates the reflected light component. Fiber Bragg Gratings (FBG) are inscribed at defined points on the sensor measuring lances, that reflect a defined wavelength. The wavelength reflected by the grating changes as a function of temperature and so indicates the temperature at the relevant measuring point. A gas cell with a fixed absorption line serves as a reference in the SITRANS TO500, against which the determined wavelength is continuously calibrated.

The transmitter sends the measured values via a Profibus DP interface to control systems for evaluation.



Simple installation and cost-effective transport due to rolled-up measuring lance

Technical specifications

Input	
FBG (Fiber Bragg Grating) temperature measuring lances	4 channels
Measured variable	Temperature
Input type	FBG-sensors (max. 48 per channel)
Characteristic curves	Temperature-linear
Resolution	0.1 K
Measuring accuracy	< 0.5 K
Repeatability	< 0,5 K
Measuring cycle	< 1 s
Measuring range	- 40 ... +1472 °F (- 40 ... +800 °C)
Unit	°C

Output	
Output signal	Profibus DP
Power supply	24 V DC +/– 20%
Measurement rate	1 Hz, irrespective of the number of sensors
Optical power	≤ 1 mW per channel
Laser protection class	Class 1

Operating conditions	
Ambient conditions	
Ambient temperature	32 ... +122 °F (0 ... +50 °C)
Relative humidity	< 80%, non condensing at 50 °C
Degree of protection to EN 60529	
Enclosure	IP20

Construction	
Weight	5.2 lbs (2.4 kg)
Dimensions	9.8 x 5.5 x 4.3 in (250 x 140 x 110 mm)

Displays and Buttons	
LEDs	• "Power on" (continuous light) • "Status" (flashing during startup; otherwise continuous light)
Pushbutton	"Reset" (system restart or address reset)

Up to 192 measuring points enable continuous temperature profiles to be determined in the smallest possible space.

The background technology: Design and operation of Fiber Bragg Gratings (FBG)

SITRANS TO500 technology is based on optical, periodic structures inscribed in fiber-optic cables, referred to as Fiber Bragg Gratings (FBG), arranged on sensor lances. The number and spacing of the FBG can be individually specified, irrespective of the application. Only one specific wavelength of the incident light is reflected.

If a wide-spectrum beam of light is directed through a FBG, the reflections of each section of the changing refractive index affect only one specific wavelength. This is called the Bragg wavelength, and is calculated as follows:

$$\lambda_b = 2n\Lambda$$

With λ_b = Bragg wavelength
n = effective refractive index of the fiber core
Λ = Distance between the gratings, also referred to as the grating period

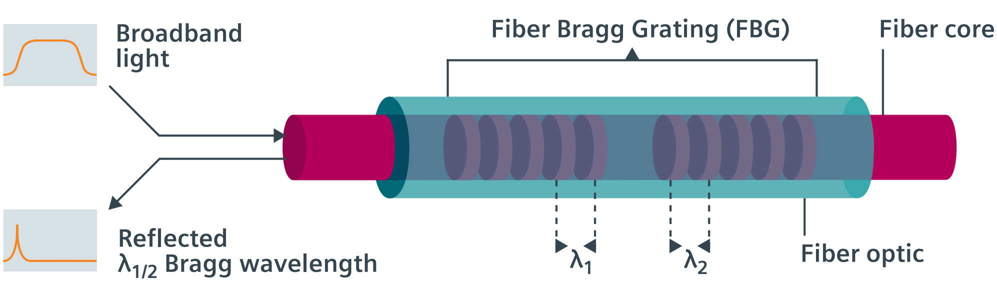
The Bragg wavelength depends on the spacing of the reflectors within the grating (Λ), thus allowing multiple gratings to be inscribed on a single fiber. Changes in the length of the fiber caused by force or heat deform the grating, and so shift the reflected wavelength. The change to the refractive index of the quartz glass is primarily due to the thermo-optic effect.

Calculation of the wavelength shift as a function of the change in length and temperature:

$$\frac{\Delta\lambda}{\lambda_o} = (1 - p_e)\cdot\epsilon + (\alpha_{\Lambda} + \alpha_n)\cdot\Delta T$$

With $\Delta\lambda$ = change of wavelength
λ_o = original incident wavelength
p_e = photoelastic coefficient
ϵ = expansion of the grating
α_{Λ} = coefficient of thermal expansion
α_n = thermo-optical coefficient (temperature dependency of the refractive index)

The first part of the expression describes the effect of strain on the change in wavelength, the second relates to the effect of temperature on the change in wavelength.



SITRANS TO500 Success Story

Background Information:

The reliable determination of the temperature profile within the catalyst filling is of crucial importance in the catalytic conversion of gases in tube and tube-bundle reactors. It has a great influence on:

- The course of the reaction
- The quality of the conversion
- The aging process of the catalyst

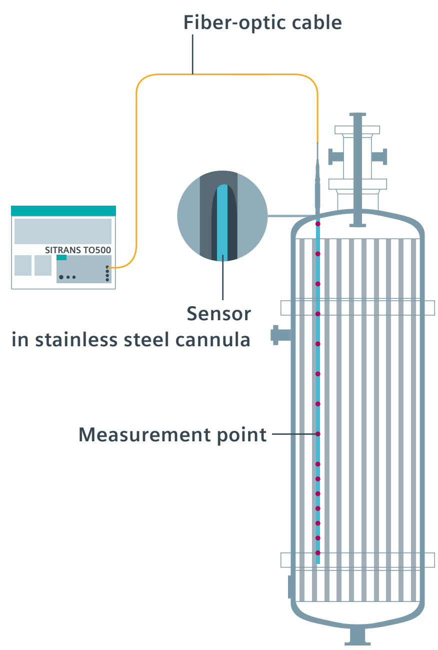
The identification of hotspots – areas with excessive temperatures that move around within the filling – plays an important role.

In use at Evonik in Marl, Germany

To meet this requirement, Siemens developed the SITRANS TO500 multi-point measuring system, which is being used successfully by Evonik in Marl. On account of the small diameter of the reaction tubes, the required number of measuring points and speed at which the values had to be measured, the use of conventional measuring technology was only possible to a limited extent. Together with Siemens, Evonik decided to use fiber-optic temperature sensing:

"The detailed recording and visualization of the complete temperature profile in the reactor enables our plant personnel to detect not only the development of hotspots in good time but also the effectiveness of the catalyst. In the first scenario, we use this information to initiate measures to reduce the temperature. In the second scenario, we can perform maintenance procedures, such as replacing the catalyst at the exact it becomes necessary due to its aging."

The use of fiber optical sensors in measuring procedures is new in the chemicals industry.



The advantages of the new system at a glance:

- Immune to electro-magnetic influences
- Chemical resistant
- Cable coupling points located directly on the eaction vessel
- Coupler can be easily disconnected for maintenance
- Measuring lance can be simply drawn out and rolled up

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