



SENSOR+TEST

2015

THE MEASUREMENT FAIR

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PRESS RELEASE

SENSOR+TEST 2015

Europe's Biggest Measurement Fair – Middle of May in Nuremberg

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Editors please note:

Using the subheadings you can find those components for your reports that are most suited for your readership. You will also find more information about the exponents described here as well as other product novelties in the ever increasing overall offerings at:

<http://www.sensor-test.de/presse/news>

The 22nd international SENSOR+TEST trade fair will be held from the 19th to the 21st of May 2015 at the Nuremberg Exhibition Center. The SENSOR+TEST is a must-go venue for developers, engineers, and users from all industries as well as for engineering and science students. State-of-the-art sensor and measuring technology is crucial for the development and sustainability of devices, machines, systems, and processes. Moreover, without the latest testing technology, the ever-increasing demands on the reliability of products and processes could not be met.

There is no comparable platform in Europe where innovative users can meet so many innovative suppliers of sensor, measuring, and testing technology from all over the globe. The AMA Association for Sensors and Measurement backer and AMA Service organizer count with 550 exhibitors and approximately 8,000 visitors.

Focal Topic for 2015: Environmental Monitoring

Environmental protection in industry as well as in general is hardly possible without reliable measuring values. Whether we want to avoid health hazards, optimize industrial processes, or comply with new statutory requirements: Precise monitoring of ambient conditions is now a more important task for sensing, measuring, and testing technology than ever before.

This is why the Exhibitors Committee in cooperation with the Executive Committee of the AMA Association for Sensors and Measurement chose Environmental Monitoring as the Special Topic for the SENSOR+TEST 2015. The spotlight is to be on systems for measuring air quality. Visitors can get a concentrated overview of new relevant products and solutions at the Special Forum in Hall 12, Stand 12-485. Moreover, the Presentation Forum in Hall 12 is to be dedicated to "Environmental Monitoring" on Tuesday, 19 May 2015.

Product Overview of the SENSOR+TEST 2015

The following text is based on the preliminary information given by the exhibitors to AMA Service, the fair organizers, up to early February 2015. It comprises a preview of products, services, and trends presented at this year's SENSOR+TEST. The structure follows the trade fair's nomenclature.

Overview of Topics:

Focal Topic for 2015: Environmental Measurement	1
Geometric Parameters	3
Mechanical Parameters	4
Dynamic Parameters	8
Thermal Parameters	11
Climatic Parameters	14
Optical Sensors / Sonic Measuring Systems	16
Chemical Sensors	19
Measuring Technology	21
Testing Technology	25
Components for Sensors and Measurement	26
Calibration Systems	27
Conclusion	28

Geometric Parameters

Determining distance, gap, position, angle, tilt, and attitude – or fill level for that matter – are among the most common measurement tasks in a plethora of applications from smartphones and automotive engineering at test rigs and with driver assistance systems to tooling equipment and robots. Thus at the SENSOR+TEST, diverse sensors for such geometrical parameters measurements can be found. They are used in smartphones, brake test benches, driver assistance systems, robots, or a plethora of other special tasks. The broad range of offers by the exhibitors demonstrates the most varied sensor principles.

In piezoresistive microswitches, for instance, mechanical changes in pressure change the electrical resistance. Sensors can do this at measuring speeds of up to 10 mm/s at a resolution of 11 nm and a scan rate of 1.6 kHz. Such sensors can be used for inline quality control of micro-optical structures in plastics or boreholes and undercuts of work pieces.¹

For inverse magneto-restriction, the magnetization of ferromagnetic sensors is changed by mechanical stress. This is used by Chinese sensor suppliers to measure distances from 25 to 3,500 mm between two points. The measuring system is largely unsusceptible to temperature, vibration, shock, and soiling.²

One of the fastest position sensors is based on the principle of laser triangulation at a sampling rate of up to 180kHz. It is available with red or blue light for hot glowing metals or organic and translucent material. The high-speed laser sensor can be used to easily determine position, distances, fill levels, road surface profiles, deformations, or vibrations.³

A miniature cable-extension position transducer with a heavy-duty measuring cable is designed specifically for test applications with high-acceleration demands as found in flight testing and automotive crash tests. The sensor has a measuring range of up to 1.50 m and can be rotated in two axes by 360°. For extreme impact applications, it can be protected by an aluminum sensor cover.⁴

The entire spectrum of conventional sensors for geometric parameters can of course also be found at the SENSOR+TEST. One example is an inductive position sensor with displacements of up to 20 mm, highly integrated, with a diameter of only 10 mm, a standardized output signal of 0 to 10 VDC, and encapsulated as per protection class IP68. It is designed for use in oil mists, rain, sludges, or dust.⁵ A robust British linear position sensor offers elastomer damped wipers and a dual-seal design for

protection class IP65 / IP67. It is used in mobile machinery and railed vehicles.⁶ Light guides with integrated fiber Bragg gratings are particularly suited for measuring sag in bridges or other static and dynamic structures and geophysical surveys. This is done by measuring the shift in the peak wavelength in relation to the temperature and/or elongation. By this means, pipelines and car batteries can be monitored for temperature and rotor blades, sail masts, and steel cables can be checked for strain. Hundreds of sensors in a measuring fiber can transmit their measuring signal over a number of kilometers to an evaluation unit without interference from electromagnetic fields.⁷

A new measurement system for monitoring land movement and loads exerted by structures can be seen at the trade-fair stand "Research for the Future" in Hall 12. Sensors are the optical cables, which including the measuring electronics, comprise fiber optical extensometers. As in a mechanical strain gauge, elongations of the sensor cables are continuously detected with a resolution in the micrometer range. In practice, this technology has proved to be considerably more robust as other fiber-optic processes, such as fiber Bragg gratings, Rayleigh or Raman methods. Since the end of 2014, this measuring system is being used to monitor a track section of the Deutsche Bahn, where landslides occurred in the past.⁸

If you want to derive behavior patterns of a system from defined parameters, such as position, angle of rotation, or speed, you need a self-learning and adaptive method to process heterogeneous data and to determine not directly measurable parameters.⁹

An ultrasound sensor with a dry-coupling measuring head can determine the liquid level of tanks and disposable containers contactless. The ultrasonic transit time between the bottom and the reflecting liquid surface and also be used to accurately determine the fill-level of foaming liquids.¹⁰

A conductive level switch made of PEEK material measures the fill level of containers and pipes. It can be used in media with low to high viscosities, detects full and empty states, and provides dry-run protection.¹¹

Mechanical Parameters

The extensive list of mechanical parameters ranges from pressure / differential pressure, force / weight, mechanical stress and torque to density and viscosity. At the SENSOR+TEST, visitors will find a number of different sensors for most of these parameters. There is no trade-fair with a broader spectrum of products and suppliers – especially when it comes to

pressure measurement. Here is the venue for discovering specialties, not the run-of-the-mill items.

Pressure, Differential Pressure

One supplier offers a miniaturized absolute pressure sensor with a resolution of 0.024 mbar and a measuring range of 10 to 1200 mbar. The QFN package contains a high-linearity silicon pressure measuring element, an A/D interface chip, and an integrated temperature sensor with a resolution of 0.01 °C. Integrated in personal navigation or location devices, the pressure measuring element in combination with an acceleration sensor can locate persons in building complexes, tunnels, or other structures, where a GPS signal cannot be received.¹²

A ceramic capacitive sensor measures pressures from vacuum to 16 bar. According to the supplier, it offers extreme precision and very good long-term stability. The sensor is equipped with various analog and electrical outputs and numerous standardized pressure connections.¹³ Thanks to their high sensitivity, piezoelectric miniature pressure sensors can detect the pressure pulses in a range of a few millibar or dynamic pressure curves up to 250 bar.¹⁴

Particularly from the versatile Chinese suppliers, who are always well represented at the SENSOR+TEST, there are reports of new developments in process transmitters. Besides the standard analog signals, many manufacturers are offering an RS485 interface or parameterization options per HART protocol. Some of these devices have an OLED display and a Modbus connection for a direct link to a PC or programmable logic controller. The applied technologies extend from piezoresistive silicon sensors for pressure measurement in liquid or gaseous media to thinfilm strain gauges. Some sensors also have integrated temperature sensors. Temperature compensation and zero-drift adjustment are integrated on thick-film PCBs. Some of the devices are scalable, have limit-value switches, and are equipped with troubleshooting functions. They are encapsulated in stainless-steel 316L housings, are intrinsically safe, comply with hazardous-area standards, such as Ex ib IIC T4, and are UL certified. Typical areas of application are petrochemicals, metallurgy, mining, power generation, water and waste-water utilities, medical and climatic technology, and tooling. With an aseptic connection per IP68 and a surface roughness of less than 0.4 µm, some of these pressure transmitters are also suited for application in pharmaceutical and food industries.^{15 16 17 18 19 20 21} One Sino-American supplier provides Bluetooth-capable MEMS pressure sensors in stainless-steel housings for heavy industries as well as prefabricated sensor modules and ceramic sensors for injection molding machines.²²

The entire bandwidth of standardized pressure transducers is obviously also well represented at the SENSOR+TEST. They range from fully encapsulated designs with thinfilm strain gauges with exceptional resistance against impact and vibration loads as well as temperatures of up to +400 °C to common pressure transmitters with silicon sensors in oil-filled capsules and standard output signals for absolute, relative, or differential pressure, and Wheatstone bridges with measuring ranges from 0 to 2500 bar, as well as high-ohm strain gauges based on nano-particles with high sensitivity.^{23 24 25} Sensors with stainless-steel housings and standardized connections per DN 25 are also available for clean-room applications.²⁶ High-temperature pressure sensors for die-casting machines.²⁷

A combined sensor simultaneously detects overpressure up to 25 bar and temperatures up +150 °C by a single gauge connection with an M10 connecting thread with a 22-mm diameter and a length of 25 mm. It can be used to monitor the power train in motor sports or autoclaves and steam sterilizers in medical technology. The piezoresistive pressure sensor does not require an oil filling and has a very high accuracy and long-term characteristics.²⁸

Switches and pressure sensors based on extremely expandable dielectric elastomer sensors (DES) measure deformations, forces, and pressures. They can distend up to 100% and can be integrated in structures susceptible to heavy deformations, such as seat occupancy sensors.²⁹ Combined with highly sensitive piezoelectric substrates, capacitive fields can be integrated in the films. They can then serve as proximity sensors. By utilizing both of these sensor principles, functions are triggered by the mere proximity of persons or objects before any actual contact takes place. This of course is particularly interesting for man-machine communication.³⁰

For wet/wet differential pressure measurement, such as on contaminated water, solvents, or aggressive gases, you can find very compact transmitters at the SENSOR+TEST, which are designed for applications in the food industry or chemical-pharmaceutical production processes. They are used for monitoring filters, fill levels, or flow. An especially small and light differential pressure sensor made of titanium is compatible to a variety of gases, liquids, and aggressive substances.³¹

A micro-manometer measures the differential pressure in the range of 0 to 2 hPa at air speeds of less than 20 m/s. This makes the instrument especially suitable for emission measurements for environmental protection. A position-independent sensor with a very good long-term stability provides high accuracy. Automatic zeroing via a built-in solenoid

valve enables long-term measurement.³² This supplier also offers a battery-operated flow meter for air, based on the calorimetric measuring principle. It provides a standard liters-per-minute (SLPM) signal. This makes corrections of pressure and temperature superfluous. Dual-range devices which can be switched between 200/ 20 NI/min and 20/ 2 NI/min are novelties. The drop in pressure is extremely low thanks to the large cross-section in the measuring tube. This enables accurate measurements especially for small system pressures. The overall accuracy is less than 1.5% of end-scale value.³³

Last, not least, the pure sensor elements and systems are also shown at the trade fair: stainless-steel capsules, for instance, with thinfilm strain gauges,³⁴ weld-on oil-filled capsules with piezoresistive sensors,³⁵ or pressure sensors manufactured in MEMS technology.^{36 37} For application temperatures up to +300 °C, there are various piezoresistive high-temperature pressure transducers based on the silicon-on-insulator (SOI) principle. These devices have a stable polarity and a deviation of the characteristic less than 0.1% full scale at the nominal pressure.³⁸

Force, Weight

As a special kind of force transducer, a piezoelectric polymer film measures high-frequency forces and pressures. A load-measurement patch is embedded directly in a car tire equipped with a miniaturized data-processing unit. Since all dynamic forces are available at the contact area between the tire and the driving surface, all relevant parameters for safety, dynamics, and comfort can be measured by one and the same patch. The scalable, high-resolution pressure sensor array can be applied to any surface to detect the smallest air flows, dynamic surface pressures of liquids as well as impacts and pressures.³⁹

Another force sensor with special strain gauges made of a platinum-nickel alloy boasts a sensitivity greater than factor 2 compared to common strain gauges made of constantan.⁴⁰ A miniature force transducer with integrated overload protection measures pressure and tensile forces in a range of 2.5 N to 100 N with great precision. Thin film strain gauges are used to detect these forces. The sensors are available with a strain-gauge output or an integrated amplifier (output signal 4 to 20 mA).⁴¹ The measurement data can be transmitted digitally via a measuring module linked to a maximum of six synchronous strain gauges. The EtherCat Ethernet field bus is particularly suited for applications requiring exact signal synchronization of less than 1 µs and efficient protocol handling. Alternatively, a CANopen bus connection is available as well.⁴²

Thematically related to these force transducers are weigh and load cells. A broad range of offers in standard and special measuring cells can also be found in Nuremberg. A low-profile shear beam load cell of only 19.1 cm height for a rated load of 500 kg would likely fall in the latter category. The data are transferred by a transmitter for top-hat rail mounting via Profinet or CANopen bus.⁴³

Torque

A motorized torque tester enables quality control of semi-finished and finished products, such as actuators or valves. Depending on the motor control commands, the measuring head, equipped with a torque sensor and encoder, moves the test piece and measures torque and angle.⁴⁴ Another system made by the same supplier measures the initial torque of torque wrenches, screw guns, or motor shafts in a range of 6 Nm to 150 Nm at a speed of up to 5,000 r.p.m. A statistics function computes the mean value and standard deviation of the current batch.⁴⁵

One of the most simple mechanical force sensors consists of only three passive components. The sensor allows contactless measurement of torque under harsh operating conditions. It makes use of the magnetostrictive principle to detect the effective forces. The sensor itself generates the required magnetic field and is thus not susceptible to magnetic interference. The sensing module is the size of a sugar cube. The areas of application are e-bikes, gear boxes, power tools, test beds for vehicle modules, and wind or gas turbines.⁴⁶

One supplier has developed a simple and inexpensive torque and angle detection method, especially suited for power takeoff (PTO) in agriculture and forestry. It boasts an accuracy of 0.5% in the range of 3,000 to 5,000 Nm. The sensor is IP65 protected and can be operated with 12 V or 24 V directly at a vehicle's power receptacle (cigarette lighter).⁴⁷ Slightly more exotic is the highly accurate steering wheel measurement system designed by the same supplier. Included are integral angular reset and torque measurement of road vehicles. The system is mounted using flanges between the steering wheel and the steering column.⁴⁸

Dynamic Parameters

The fact that automotive development in Germany is an especially important topic is reason enough for the SENSOR+TEST to be the most prominent platform for accelerometers, vibration, oscillation, and acoustic analysis systems – not to forget the development of the many speed and flow sensors driven by microsystem technology (MEMS).

A new generation of accelerometers combines the benefits of piezoelectric sensors (very high frequency range) with sensors of variable capacitance

(true DC response) in a single housing. Static acceleration, as occurs in curves in measuring ranges of 20 to 200 g, as well as quasi-static vibration in the sub-1Hz range and high frequency vibrations up to 10 kHz can now be measured using one and the same sensor. The sensors have a 4-pin M4.5 x 0.35 radial connector for signal and power supply. They are hermetically sealed in a titanium housing. Areas of application are in aerospace testing, health and usage monitoring systems (HUMS), wind turbines, or machine monitoring.⁴⁹

Triaxial measurement systems are of interest not only in the area of mobility, but also in buildings. They monitor wind power plants and other big structures, such as bridges, towers, and pipelines. For high precision requirements, the commercially available 3D inertial systems based on fiber-optical sensors are increasingly being replaced by the more compact and less expensive MEMS-based sensor systems. One supplier now uses the technology originally meant for the consumer market for industrial-grade sensors. Robustness, stability, and accuracy are assured by new high-tech algorithms and error modeling.⁵⁰

A supplier from Berlin presents capacitive inclination and acceleration sensors at the SENSOR+TEST based on single crystal silicon and the latest micromachining processes. The miniaturized acceleration sensors (MEMS) attain a very high signal-to-noise ratio and an excellent temperature stability. They can detect the smallest changes in inclination or acceleration.⁵¹ Another supplier has the optimized processing algorithms for such inclination and acceleration sensors. Besides acceleration, rotary speed, and compass values, they can output Kalman filtered data, such as 3D orientation and quaternion. Typical applications besides geo-engineering and condition monitoring are found in the area of fitness. By means of a special integrated function, the number of steps, distance, activities, rest periods, energy consumption, and other values can be output. Wearable interfaces, such as Bluetooth LE, NFC, ZigBee, or Wifi, and supplementary functions, such as GPS and barometer, are already integrated for the consumer area.⁵²

Piezoelectric vibration sensors find applications at temperatures of +538 °C (+1000 °F). They have a "silver window" on the top of the hermetically sealed Inconel housing, which supplies the sensor element with oxygen, while maintaining the seal. The sensor weighs only 5 g, is 9.9 mm big, and supplies a signal of 1 to 2 pC/g at bandwidths of 10 kHz. Areas of application are turbines, vehicle engines, or environmental stress screening (ESS) applications. Suitable fiberglass-sheathed stainless-steel cables are available.⁵³ This manufacturer also has a piezoresistive MEMS accelerometer with an ATEX certificate. It is shock resistant up to 10,000 g and can be used in measuring ranges from ± 2 g to ± 2.000 g for the most varied static and dynamic applications. It is gas damped to avoid

resonances and temperature compensation ensures stable measuring values. performance in various operating environments. The hermetically sealed sensor is suited for impact and structural testing, test applications, environmental simulations, and vehicle tests.⁵⁴

Torsional vibration of rotating machinery comes from the instantaneous angular velocity variation of the rotating parts. This widespread phenomenon appears on reciprocating machinery (diesel engines, pumps, compressors), air and water propellers, wind turbines and their transmission. This is the major cause for the failure of structural elements, audible noise, and vibration. One supplier offers an integrated torsional vibration measurement solution by analyzers equipped with 6 torsional inputs and an edge resolution of 6.4 MHz over sampling.⁵⁵

Also offered at the SENSOR+TEST is software for balancing rigid and flexible rotors in up to 14 planes. Depending on the number of balancing planes, one or two accelerometers and a speed sensor are needed. The software imports the measuring data of the test runs for amplitude, phase speed, and rotary speed. It then calculates the unbalance, the correction masses, and determines the residual unbalance.⁵⁶ This supplier also has software for structural analysis. Besides the classical modal analysis with excitation by impulse hammer or shaker, natural harmonics, damped frequencies, and oscillation modes of a structure can also be analyzed during operation, without excitation impulses.⁵⁷

By using a combination of GPS and inertial sensors, a speed sensor can be designed that negates the disadvantages of each contributing methods and supplies precise data for acceleration, speed, or distance for brake tests. The settings for braking distance calculations are configured quickly and easily in a browser application. A CAN interface provides real-time data in ISO standard format. Optionally, the distances or relative angles between a number of vehicles can be measured in centimeters. That makes the device an economical alternative for evaluating driver assistance systems.⁵⁸

Laminar flow elements for measuring air volume are used in human medicine for measuring vital capacity. These elements have become popular in technical areas as well. Laminarization of the flow is performed by capillary bundles. The differential pressure is only 1.5 mbar. This lets the transducers carry out measurements of large air flows of up to 600 l/min at low system pressures, such as occur in isokinetic air-flow sampling for environmental protection applications.⁵⁹

Small, smart, and low-cost disposable flow sensors may change the administration of medication from the ground up. These sensors can

measure flow rates in real-time in infusion tubing or catheters, making it easier to monitor and control the treatment.⁶⁰ An analog mass flow meter for artificial respiration and anesthesia is offered by a Swiss supplier. In a gas channel of the flow meter is a temperature sensor that enables very exact temperature compensation. The sensor measures the flow rate of air and other non-aggressive gases in a range of -24 to 240 slm.⁶¹ You can monitor the gas consumption reliably in real-time with a smart gas counter. The mass flow meter is based on the micro-thermal measuring principle, is completely calibrated for air and natural gas, and has a standard connection as well as an I2C interface. The sensor and the evaluation circuitry are integrated in a single CMOS chip.⁶²

Thermal Parameters

The market for temperature sensors and measuring devices seems endless in regard to size and variety. You can get this impression of the SENSOR+TEST every year. Besides standard sensor elements, such as NTC, Pt100/Pt100, or the numerous types of thermoelements, contactless temperature measurement is strongly represented.

Platinum temperature sensors are regarded as robust, long-lasting, and reliable. They are characterized by good vibration resistance as well as fast responding qualities. They can also detect temperatures in a range of several hundred degrees. Since soldering of the nickel connection wires has been difficult for some sensors, this supplier provides pre-tinned temperature sensors.⁶³ Explosion protected and intrinsically safe thermoelements and resistance thermometers with ATEX / IECEx certification can also be found in Nuremberg.⁶⁴ This includes encapsulated thermoelements for applications in the chemical industry, power plants, and test stands.^{65 66}

With a power consumption of 60 μ A, an SMT temperature sensor can be applied wherever items of the "Internet of things" are found and their temperature in the range of -45 °C to +130 °C needs to be monitored. The sensor has a pulse-width modulated output signal, whose pulse rate is proportional to the measured temperature value. This allows the sensor to be connected directly to an MCU (multipoint control unit), without an A/D converter.⁶⁷

High precision glass resistance-thermometer in all shapes (cylindrical, different cuts, etc.) and varieties (heads, plugs, cables, etc.) and in various dimensions (fitting, immersion length, etc.) are to be found at the SENSOR+TEST. The thermometers are optimized for fixed or hand-held applications and are highly resistant against acids, alkaline solutions and

solvents. Thanks to the very small immersion depth, heat input or dissipation is very limited.⁶⁸

A transmitter converts the resistance values of Pt200 thermometers into a 4 to 20 mA signal. The signals are not influenced by cable lengths, connectors, or electromagnetic fields. The measuring range of the transmitters extends from -20 °C to +950 °C. Thus, all temperature-critical components and processes in exhaust systems can be monitored.⁶⁹

Temperature Measurement Devices

The SENSOR+TEST presents a comprehensive portfolio of innovative contactless temperature measurement devices, such as infrared (IR) pyrometers and infrared cameras for spot, line, or scanning measurements. One method of reliably monitoring molded parts produced by injection molding is thermography. Real-time thermography in HD quality is offered by an infrared camera with latest-generation high-resolution micro-bolometer detectors with (1,024 x 768) or (640 x 480) IR pixel formats. In combination with the optomechanical MicroScan technology, the native detector resolution is quadrupled. Thus, depending on the detector format, geometrical resolutions of up to 3.1 Megapixels can be attained. Luminously-intense IR precision optics ensure that the smallest temperature differences of less than 0.03 K can be detected among measurement objects.⁷⁰

Heat-flux sensors measure heat flow or temperature differences. A Swiss manufacturer is showing sensors with a temperature gradient resolution in the nano-Kelvin range and for heat flux in the micro-Watt range. The sensors are available in various form factors and can be soldered, clamped, or bonded. Combined with other sensors, they can measure flows, generate temperature profiles of materials, compensate thermal effects, and detect calcification or icing.⁷¹

Explosion-protected pyrometers monitor flame temperatures to within 0.3 °C in a range from +350 °C to +2,000 °C. Applications are found in refractory lining of furnaces in sulfur recovery plants. Special algorithms are used to analyze the temperature values, providing an accurate picture of the activity in the furnaces.⁷² The same supplier also offers an infrared system for monitoring the pilot flame of flare stacks in refineries. This is usually done with thermocouples, which however can cause premature failures due to the heat generated by the flaring process. This new system not only monitors the pilot flame and ignition, but the flare stack and its smoke as well. It comprises non-contact infrared sensors, high-quality sight-through optics, dual outputs, and CSA/US, KEMA, and ATEX explosion-proof housings.⁷³

The advent of high-voltage (HV) modules in vehicles, providing important for optimization of the vehicle and its component layout, has resulted in a new demand for safe temperature measurement. One manufacturer is now offering HV measuring modules for stationary application, which have been approved by an accredited test lab as per safety standard EN 61010. The compact modules are available in protection classes IP50 and IP65.⁷⁴

Temperature Probes

At the SENSOR+TEST 2015 you can choose from about 600 temperature sensor elements, the focus being on Pt, NTC, or KTY types. Customized designs for medical technology, racing, energy technology, or measuring and control technology in general, all of it is on offer. Thus, you could integrate a wireless temperature sensor in a smart metering infrastructure as a room sensor. Albeit this has already been done for you. The protocol is compatible to Wireless M-bus open-metering specification (OMS).⁷⁵ The supplier of this sensor has a complementing wireless, battery-operated temperature and humidity data logger, designed for particularly harsh ambient conditions, such as exist in refrigerated warehouses or during hygienic applications. A precision real-time clock and a nonvolatile memory allow the intermediate storage of up to 5,000 temperature and humidity values. The data is read via a WLAN connection. Thanks to the extremely low quiescent current, the service life of the battery is at least 15 years according to the manufacturer's data.⁷⁶ Another supplier has developed a transducer for temperature and humidity measurements in hazardous areas. The replaceable probes are in a stainless steel housing and EX certified for environments with ATEX and IECEx requirements. Thanks to a sophisticated circuit design with galvanic isolation, no intrinsically safe power supply is required for this low dew point probe.⁷⁷

Arriving from Taiwan are contactless measuring infrared thermopile sensors based on MEMS with an analog output or fully integrated A/D converter. To reduce Johnson noise, the sensor has a thermistor referencing the ambient temperature.⁷⁸ Pyrometers for the near infrared range are contained in an IP65 stainless-steel housing, have a response time of 10 ms, and a measurement field diameter of 0.7 mm. A double laser is used as an aiming aid. The output comprises temperature values via a 0 to 20 mA interface and a galvanically separated RS 485 interface with a Modbus RTU protocol.⁷⁹ The optical alignment of a shortwave pyrometer to the measuring object is done with a laser targeting light, view finder, or optionally with an integrated camera module. Depending on the model, the measuring ranges are from 50 °C to 3,000 °C. The image is shown on a monitor or transferred the InfraWin software by an external video grabber.⁸⁰

Precise control of temperature distribution in continuous float glass production is the most important prerequisite for controlling various glass characteristics, such as internal stresses and other mechanical attributes. Non-contact infrared radiation thermometers in the spectral range of 5 μm are subject to strong noise below +300 °C. In the range beyond 8 μm , the background radiation is reflected. This is why one supplier combines IR radiation thermometers in the spectral range of 7.5 to 7.85 μm with a line scanner to make a fast and highly precise device for measuring the temperature distribution in glass.⁸¹ For process monitoring, especially in high temperature ranges, high and low temperatures must be measured simultaneously. Thus another manufacturer is showing a new high-temperature IR camera with a continuous measuring range from +600 °C to +1,500 °C and from +1,400 °C to +3,000 °C. The 768 x 576 pixel IR camera has a measuring frequency of 50 images per second and operates in the near infrared range between 0.8 to 1.1 μm .⁸²

If do not care to measure only objects, but rather their temperature distribution as well, Nuremberg is the venue where you can find ration pyrometers with IR imaging. Here the pyrometer measures the temperature at a central measuring point and the IR camera auto-calibrates to the measured temperature via an infrared filter.⁸³

Climatic Parameters

This section is mainly about a combination of humidity and temperature measurements. There are also plenty of sensors for barometric air pressure, atmospheric gas concentrations, smoke, dust, or solar radiation, for that matter, all of which can be found at the SENSOR+TEST.

A miniaturized 24-bit sensor module, called „the world's smallest weather station" by the manufacturer, comprises a capacitive humidity sensor, a piezoelectric measuring cell, and a suitable ASIC. The digital PTH (pressure, temperature, humidity) sensor is packaged in a 5.0 x 3.0 x 1.0 mm³ QFN chip housing. It can be integrated in smartphones, printers, household appliances, HVAC (heating, ventilating, air conditioning) systems, or weather stations.⁸⁴ The first pre-calibrated, linear D/A humidity and temperature sensor is being presented by a Swiss supplier. It is equipped with an analog ratiometric voltage output. The sensor is on a chip with a 2.5 x 2.5 mm² footprint and height of 0.9 mm – and thus one the smallest humidity sensors for applications beyond 2.4 V on the market.⁸⁵ A Korean manufacturer is showing the automatic MEMS weather station with an SM bus for digital sensors and data logger – a worldwide first according to the supplier.⁸⁶

In the future, many measuring devices will have wireless communication capabilities. A digital sensor measures humidity, temperature, and CO₂ content and transmits the measured data to receivers at a distance of up to 600 m. A multipoint CO₂ and temperature adjustment creates outstanding CO₂ measuring accuracy across the whole temperature range. Power is supplied by commercially available batteries. Thus, this sensor is suited for room monitoring tasks as well as for agricultural, industrial, and warehousing applications.⁸⁷ By means of a miniaturized capacitive measuring cell based on a dielectric polymer film and integrated bandgap temperature probes, a humidity sensor and processor are able to measure absolute humidity. The sensor attains an accuracy of $\pm 3\%$ RH in a measuring range of 20-85% RH. The sensors are available in a 3.0 x 3.0 x 0.9 mm³ DFN package.⁸⁸

For reliable trace humidity measurement, a German supplier has developed a low dew point probe to precisely measure the low dew point and temperature in pressurized environments. The probe has a measuring range from -70.85 °C Td / -40 to +85 °C. The stainless-steel probe and its accessories withstand pressures of up to 100 bar. This low dew point probe is used in compressed-air systems, refrigeration driers, and adsorption driers. An EX-certified version is available for ATEX environments.⁸⁹

The overall heat transfer coefficient, U-value (or U-factor) is the measure for assessing the heat loss of a building element. It describes how much heat (in watt) passes through 1 square meter of a given material, when the temperature difference between its two sides (e.g. the exterior and interior of a building wall) is 5°C. A Swiss supplier has recently developed a U-value kit, including a highly sensitive heat flux sensor, two temperature probes (one for indoor, one for outdoor use), a data logger, and computation software. The measurements can be followed on a laptop and the measured values can be further processed by other programs.⁹⁰

A German manufacturer has made an energy-efficient and highly precise 18-bit signal conditioner with an integrated 24-bit digital signal processor (DSP) for linearization and calibration functions. It has a typical power consumption of 1 mA and only needs 20 nA in standby and can be equipped with barometric air pressure and thermopile sensors. The areas of application are measurement of barometric altitude for portable navigation devices, emergency call systems, pressure measurements inside hard disks, and weather forecasting. Thermopile sensors can be used to enable contactless temperature measurements of objects or human body temperature.⁹¹

Optical Sensors / Sonic Measuring Systems

There are plenty of application fields for optical sensors: gas and particle measurement, fluorescence and analysis techniques, spectroscopy, temperature measurement, motion detectors, high-resolution positioning systems, etc. Among the major characteristics besides sensitivity relative to wavelength is always the signal-to-noise ratio. Not only sensors are used in these applications, but special light sources as well – laser diodes mostly.

Panchromatic PIN photodiodes and InGaAs detectors with an active surface area of 1.3 mm^2 detect 70% more signals compared to a detector with a 1 mm diameter. These are packaged in a TO housing with a 4.8 mm cap diameter. Depending on the series, they have response times of 1.700 ns, 2.200 ns, or 2.600 ns.⁹² The basic material of pyroelectric detectors with the highest performance level is DLaTGS, deuterated and L-alanine-doped triglycine sulfate. The detectivity D^* of DLaTGS is typically 2.5 to 5 times higher than in LiTaO₃ detectors, even at high frequencies. Moreover, they have a wide spectral sensitivity range from UV to THz wavelengths that is only limited by the detector window used. One supplier now has pyroelectric detectors on offer with various active surfaces, different sizes and shapes. Standard housings include TO-5, TO-66, and TO-37.⁹³

Optical absorption analysis can analyze components having chemical or physical similarities. LEDs and photodiodes for the range of 1,500 to 5,000 nm can examine practically any probe in any state, liquids, solutions, pastes, powder, fibers, gases, or surfaces.⁹⁴

One supplier delivers dichroic glass polarizers with high contrast and very good transmission characteristics. Elongated silver nano-particles cause a waveform and polarization dependent absorption of incident light. Unpolarized light is linearly polarized, while polarized light is blocked relative to the polarization axis. These polarizers are used in industrial measuring technology as photoelectric sensors, polarimeters, and interferometers as well as in optical communications technology.⁹⁵

Optimized for scintillator luminescence detection in the visible wavelength range, X7 PIN photodiodes detect ionizing radiation in container and baggage scanners. Housed in an ultra-flat chip-scale package (CSP) with a footprint nearly the same size as the actual semiconductor die, can be assembled to form larger linear or matrix arrays with very high fitting accuracy. The chip is mounted on the carrier with its active area and electrical contacts facing down.⁹⁶ Optimized for measurement of chemical luminescence is a photo-detector module (PDM) for the spectral range of 200 to 600 nm. It can be connected to a multi-channel scaler/counter timer module with a trigger input and a USB interface.⁹⁷ An extensive

wavelength range of 780 nm to 3,300 nm is covered by super-luminescent diodes in cooled (TO-3 and butterfly) or uncooled (TO-56, SOT-148, coaxial) fiber-coupled and free-space packages.⁹⁸

For thin-film coating or growth processes in glass finishing and semiconductor processing, the quality of the coating thickness and the refraction index of the coating must be assessed. A compact sensor measures the polarization-dependent reflection of two single-mode lasers under various angles of incidence. The sensor works without moving parts and is designed for applications in harsh environments.⁹⁹ Also presented are technology modules for non-polarizing and polarizing beam splitters, VCSEL-based lighting components, and 4-quadrant photodiodes in a successfully tested function demonstrator the size of a matchbox.¹⁰⁰ New line-scan image sensors have a resolution of 1,024 to 4,096 pixels and are designed for OTC (Optical Coherence Tomography) as well as for surface and print inspections, aerial mapping, and industrial process control.¹⁰¹

Infrared cameras provide real-time thermography in HD quality. The core consists of two high-resolution micro-bolometer detectors with 1,024 x 768 or 640 x 480 IR pixel formats. In combination with the optomechanical MicroScan technology we have a quadrupling of the native detector resolution. Depending on the detector format, geometrical resolutions of up to 3.1 Megapixels can be achieved. Luminously-intense IR precision optics ensure that even the smallest temperature differences of less than 0.03 K can be reliably detected among measurement objects at a frame rate of up to 240 Hz.¹⁰²

The "fill level" of a room can be determined by the intelligent sensor systems of a German supplier. The integrated software detects the environment in 3D and identifies objects and persons. Areas of application are counting of persons, their length of stay, admittance control, and behavior analysis.¹⁰³ One research facility combines any terrestrial 3D laser scanner with its software to measure rooms in buildings, production plants, and tunnel systems, without any additional positioning sensors. As opposed to stationary systems, this system can also measure when the object is in motion or being moved, e.g. on a conveyor belt.¹⁰⁴ For the surveillance of wider areas or greater distances, one supplier arranges optical sensors in a patented pattern and synchronizes them mechanically, electronically, and with software in such a way the entire area under surveillance can be monitored from a single location with a stable resolution, high dynamic range, and consistent depth of field. The sensor concept is complemented by thermal sensors to further improve the analysis of their data.¹⁰⁵ This supplier has also developed a high-performance, self-learning video analysis system that continuously adapts the system parameters to the current environmental conditions.¹⁰⁶

The blood flow velocity under the skin is measured by a miniaturized optical sensor. The sensor principle is based on the laser Doppler method. This is done by elastic scattering at the mobile blood components. The resulting shift in the wavelength of light can be measured by coherent superposition with the excitation light.¹⁰⁷

Avalanche photodiodes are very sensitive and fast. One supplier in Nuremberg will show a semiautomatic assembly unit, where fibers can be adjusted exactly to within a few micrometers. Thus, coupling efficiencies of almost 100% are attained. The pigtailing technology can be implemented for almost any combination of APD and fibers with a core diameter of less than 600 μm . Fiber coupling advantageous in medical technology or analytical measurement technology. Since the detector is not near the measurement area, greater spatial freedom is available and disruptive signals can be suppressed with an opaque fiber jacket.¹⁰⁸

Sonic Measurement

Thanks to the big topics dealing with measuring and testing technology – especially in the area of vehicle development – visitors to the SENSOR+TEST can obtain information on the state of development of measuring microphones and acoustic measuring technology in general.

Based on MEMS technology, a fast mass flow sensor determines the acoustic particle velocity by measuring the temperature difference in the cross section of two extremely thin platinum wires placed in parallel. , this extremely fast mass flow sensor is capable of monitoring the movement of air particles. Any sound field is described completely by both the scalar value sound pressure and the vector value acoustic particle velocity. This allows for better location of sound sources, testing Micropore leaks, or non-contact measuring of vibrations.¹⁰⁹ As an alternative to Kundt's method, the same supplier presents an acoustic camera that measures impedance, reflection, and absorption of flat or curved surfaces. In situ the camera works with the relative movement between sample and probe, offering a high spatial resolution of inhomogeneous or perforated materials.¹¹⁰

With an electronic control unit, an air mass meter can be turned into a universal flow meter. Flow generates 1.0 to 4.5 volts output voltage depending on the gas speed. This allows flow monitoring in air ducts, buildings, and air conditioning systems as well as the air path of stationary engines and cogeneration plants (CHP).¹¹¹

For dynamic applications in harsh environments, one manufacturer is offering encapsulated multilayer actuators with improved heat dissipation. A casting compound that does not impair the actuator displacement

replaces the inert gas in the hollow space between metal bellow and piezo actuator. This enables frequencies that are ten times higher than with an actuator without casting compound.¹¹² Also developed by this supplier is a lead-free ceramic material based on modified bismuth sodium titanate (BST) that is suited for industrial ultrasound applications in the MHz range.¹¹³

Chemical Sensors

Sensors for determining the concentration of combustible, explosive, toxic, or other gases, have been at the focus of the SENSOR+TEST for years. In the reports submitted by the exhibitors this year, optical processes are again emphasized. Alongside catalytic sensors, there is a wide offering of wet chemical sensors for pH value, oxygen concentration, or conductivity.

Gas detection devices can be used over a wide wavelength range of 760 to 2,150 nm. DFB laser diodes allow excellent SMSR and narrow-line width as well good tuning characteristics with mode-hop free tuning of less than 2 nm. This lets you detect most common gases.¹¹⁴ To quickly detect leaks in pipelines, you can use a methane sensor developed in Japan with a high sensitivity for low concentrations.¹¹⁵ Also developed by this enterprise is an ammonia sensor, characterized by a low temperature dependence to find leaks in refrigeration units, and a hydrogen sensor with a good selectivity for organic vapors.¹¹⁶ Based on laser scatter technology, a measuring device determines the concentration of particle masses in diesel combustion engines.¹¹⁷ Also presented at the SENSOR+TEST are gas sensors with photoacoustic spectroscopy for monitoring load tap changers and transformers. They measure the overall concentration of sulfur hexafluoride (SF₆) in the enclosed space of gas-insulated switchgears.¹¹⁸

Battery-operated electrochemical sensors are being offered by a Japanese manufacturer. Thanks to weak alkaline electrolytes, the electrodes are not damaged. By optimizing the sensor's internal structure, the evaporation speed of the water reservoir is minimized. This ensures excellent stability and an expected sensor life of up to 10 years.¹¹⁹ Also battery operated are fluorescence-based optical XYO oxygen sensors for measuring ambient oxygen partial pressure (ppO₂) from 0 to 300 mbar. The integrated pressure sensor determines the oxygen concentration. Thanks to the non-depleting sensing principle, the optical XYO sensors provide a much longer lifetime compared to electrochemical oxygen sensors. Also, the fully compensated sensors are not influenced by temperature or barometric pressure changes. Typical applications include respirators, high altitude training, confined space monitoring, fire prevention, oxygen analyzers, laboratory equipment, and agriculture.¹²⁰

Nanotechnology was one of the major topics in scientific discourse. Especially engineered nanoparticles (ENPs) are ready for use, without proof of their harmlessness for organisms and the environment. A Rumanian supplier presents a sensor for quick analysis of nanoparticles in cosmetics, food, and beverages. The system combines an optical process with an electrochemical one. Using learned patterns, the optical sensor array evaluates the automatically prepared samples for size, size distribution, and refractive index. At the same time, the electrochemical sensor determines conductivity, surface characteristics, and the chemical composition.¹²¹

A conductivity sensor detects product changes and phase separation in food-processing and pharmaceutical plants. It is based on the conductive measurement principle, measuring ranges from 1 μS to 15,000 $\mu\text{S}/\text{cm}$, with response times below 0.5 s – even with highly viscous or lumpy media.¹²²

A Scottish supplier is showing MIR devices comprising arrays of proprietary pyroelectric detectors. They can characterize a range of liquids, slurries, oils, solids, and even gases. Applications include analysis of lubricant oil, petrochemicals, and medical diagnostics.¹²³ Another supplier is offering high-grade sensor for professional applications in process and industrial measuring technology. They are designed as combined single-rod measuring cells and measure the pH and redox potentials in a variety of applications. They are robust and work in complex processes with increased contamination and toxic cargo or in mediums containing oil at temperatures up to 135 °C and 13 bar pressure.¹²⁴

Another major topic among gas sensors this year is air quality. An inexpensive complete system detects CO₂ and optionally oxygen concentrations.¹²⁵ Two superlatives at once are claimed by a Japanese supplier: an air-quality sensor with the world's smallest size of 3.2 x 2.5 x 0.99 mm³ and with the world's lowest power consumption of 15mW. The areas of application are home and office applications for monitoring air filters, air conditioners, and air blowers.¹²⁶ Room sensors are needed for demand-controlled ventilation systems. They measure the carbon-dioxide content and temperature of the air. For CO₂ measurement, a second-generation carbocap sensor is used that has a novel micro-glow light source. The internal reference of the CO₂ sensor guarantees the best stability and operation even in constantly occupied buildings without the need for frequent readjustments.¹²⁷ Other humidity and temperature transmitters made by the same supplier are designed for areas which are hard to access, high pressure and vacuum applications, or high-temperature tasks. The areas of application are clean rooms, pharmaceutical processes, swimming pools, vacuum chambers, and

baking ovens.¹²⁸ The MEMS sensors supplied by a Rumanian manufacturer measure carbon dioxide and methane.¹²⁹

Measuring Technology

At the SENSOR+TEST, measuring and testing technology can also be found outside its own hall at the stands of many other sensor exhibitors. The offerings include complex measuring systems for test beds, decentralized monitoring of engineering structures, machines, and plants or handheld measuring equipment and devices for process instrumentation . Also there is mobile measurement technology, mostly for application in automotive development. Visitors can experience that live in test drives.

To meet the demand by users for more channels, faster sampling rate, and more accurate results, a USB measuring model was developed. It has 32 analog inputs, a 1-MHz A/D converter, and 20-bit A/D resolution. Additionally, users get 32 digital I/O channels and five counters/timers.¹³⁰ A measuring amplifier for dynamic measurements with piezoelectric sensors also works with a 24-bit A/D converter. For vibration analysis or pulsation pressures, single-channel or four-channel amplifiers can be queried from a browser via Ethernet.¹³¹ SMT measuring amplifiers are being developed further. One supplier is designing his amplifiers for signal conditioning of current signals and IEPE sensors. Individually galvanically separated measuring channels and sampling rates of 100 kSPS/Ch as well as adjustable FIR filters are additional features.¹³² A highly integrated digital I/O device is presented in Nuremberg by another manufacturer. At each of the 16 digital inputs and outputs voltages (max. 32 V) and currents (250 mA per output) can be detected and output. Of interest are also the two 32-bit counters with quadrature decoders, which can be accessed via the first digital inputs.¹³³ Dual-channel function generators with an LXI-capable LAN interface and a USB port facilitate the integration in individual measuring systems. The two channels can be used or adjusted centrally or individually, making modulation of channel-independent signals for AM, FM, PWM, Sum, FSK, BPSK, and PRBS easier.¹³⁴ A chip for highly precise signal amplification and sensor-specific measuring-value correction for highly resistive bridge sensors as well as the data acquisition for thermoelements is presented by another supplier. The measuring values are output digitally via SENT 3.0 or I²C.¹³⁵

A data logger with a 5.7-inch touchscreen is operated via icons. Measuring values, peaks, mean and limit values can be displayed as lists, bar graphs, or line charts. Analog sensors as well as digital sensors can be connected to ten galvanically separated measuring channels. A connection plug boasts its own processor including A/D conversion. It can store up to ten channels for measuring and function values, especially for multisensors and for connection of complex devices, such as chemical analyzers or

energy analyzers. These work parallel to the sensor-specific measuring rate and thus attain high transmission rates.¹³⁶

Another handheld data logger, albeit for wireless transmission of data, is presented by a different measuring enterprise at the SENSOR+TEST. The device can transmit measuring data peer-to-peer, via LAN, or WAN connection to mobile devices or PCs. Thus, a gardener or farmer can get a quick overview of the parameters essential for plant growth: temperature, humidity, carbon-dioxide content, as well as light and UV intensity. The supplier offers a special software application to evaluate these parameters on the target device.¹³⁷

For uninterrupted measurement of currents in conductors with any kind of geometry, you need flexible current transformers. Together with frequency-selective measuring devices, they are a universal combination for determining AC currents in a range of 20 Hz to approximately 100 kHz. That lets you measure even the smallest signal currents of just a few milliamperes to more than 20 A exactly even under considerable amplitude noise. A supplier manufactures robust current transformers for temperatures in the range of 20 °C to +55 °C and protection class IP54.¹³⁸ This supplier also offers a mobile insulation and contact failure locator. For instance, it can find line breaks, short circuits, and transition resistances inch by inch in railway traction power supplies. Faults are detected by signal tracking. The operating frequencies of track circuits, trap circuits, automatic train control, and loop detection equipment (track loops) are used as test signals.¹³⁹

Tablets are becoming ever more prevalent in measuring technology. A German supplier is showing the first tablet oscilloscope. All functions can be accessed by swiping or tapping. The big 10.1-inch display provides a clear, uncluttered overview.¹⁴⁰ Handheld oscilloscopes are suited for measurements in the lab or in on-site maintenance services. They weigh 1.4 kg and 60 mm thin and have 5.7-inch touchscreen and integrated oscilloscope, multimeter, and recorder functions. The two oscilloscope inputs and the multimeter input are electrically insulated.¹⁴¹

With a single-channel or four-channel 24-bit charge amplifier, you can integrate piezoelectric force, pressure, and acceleration sensors in NI CompactRIO applications. In the past, you always had to connect an external amplifier that would convert charge signals to voltage values first. Depending on load level, you can now detect signals up to 20 kHz at a sampling rate of up to 50.78 kSps. For lower frequencies, the module offers the option to detect slow force progressions and quasi-static measurements near 0 Hz.¹⁴²

New precision measuring modules for sound and vibration analysis have eight or 16 analog inputs for the direct connection of IEPE/ICP sensors, such as measuring microphones or acceleration sensors, two 32-bit analog outputs, digital I/Os, a 32-bit tachometer input, and three counters. Four additional modules can be linked via a sync port to create a powerful vibration measuring system with up to 64 synchronous inputs.¹⁴³ Another supplier is showing a complete mobile system for data acquisition with six dynamic channels.¹⁴⁴

The magnetic-field distribution of permanent-magnet rotors can be measured by a triaxial motor scan with a built-in minicube magnetic-field camera over the full rotor surface with a high resolution in radial, axial, or other direction.¹⁴⁵ The smallest intelligent battery sensor is 0.85 mm high and has a footprint of 5 mm x 5 mm. It has two highly precise 18-bit sigma/delta ADCs with integrated voltage reference and needs less than 100 μ A in sleep mode. Besides the automatic start/stop function for automotives, the sensor can also be used in industrial and medical systems.¹⁴⁶

Monitoring Tasks

A data logger is designed as a bridge module for static and dynamic strain measurements as well as structural testing in aerospace applications. A single module enables connection of 8 strain gauges in full-, half-, or quarter-bridge configurations.¹⁴⁷ A decentralized system is designed for long-term measurements on structures, such as bridges, buildings, or railway sidings (roadbed) as well as for the detection and monitoring of environmental conditions. The devices are in a LAN and available for a variety of parameters.¹⁴⁸ Developed especially for geological and geophysical measurements is a mobile system for self-sufficient detection, storage, and evaluation of seismic data.¹⁴⁹

Another manufacturer promises a low-cost indoor localization and navigation system. This is done by sensor modules and Wi-Fi access points, with which users can build their own tracking and locating applications. The system has accuracy steps of ± 2 cm to ± 1 m. Areas of application are large industrial halls and logistics warehouses, material handling tasks, production lines, tool tracking, and autonomous vehicle and transport systems.¹⁵⁰

For reasons of cost and size, radar systems were only used to a limited extent. However, one supplier is now showing a compact, modular W-band radar, which is capable of detecting small objects at a distance even at low visibility with a measuring resolution of up to 20 μ m. Areas of application are object identification, object protection, hindrance detection, and collision prevention.¹⁵¹

RFID Applications

RFID tags are needed for many applications, in which quick and reliable identification is paramount, for instance in supply chain management, tracking of products and other items, as well as for access control. At the SENSOR+TEST, one manufacturer is showing tags with a new I²C interface for reading from and writing to the internal memory. Thus, the tag functions not only has an RFID function, but can also be used as a wireless data interface. The tags work with and without an antenna at distances of a few millimeters up to ten meters.¹⁵² Another transponder chip, ISO 1443A (NFC 2) compliant, stores measuring results from on-chip high-precision temperature sensors at a configurable interval of 100 ms to 10 h.¹⁵³

One RFID sensor data logger in half-smartcard format stores measured sensor values at a defined interval with a timestamp. Besides setting the measuring interval, sensor limits can also be set to define when and how the up to 8,000 measuring samples are to be read out and to determine whether the set limit values were kept. The system can thus be used in quality-assurance monitoring for the transport of foods, plants, pharmaceuticals, or medical products.¹⁵⁴

For monitoring tension in building structures, cables, and cable ducts and for cyclical long-term monitoring, there is a handheld RFID data logger that can detect and store up to 500 measuring values from force sensors. Each RFID transponder has a unique 48-bit ID number, works passively, and is maintenance-free. Power is supplied from the data logger during the actual measurement.¹⁵⁵

Batteryless temperature sensor-transponders were developed on the basis of the RFID technology for passive measurement of physical parameters, making measuring cables superfluous. An RFID tag is being presented that has an NTC resistor with a measuring range of -10 °C to +120 °C and accuracy of ± 0.5 °C or an expanded temperature range of -30 °C to +300 °C. Encapsulated in an IP 67/68 housing, it can be used for rotor temperature monitoring of motors or generators for asset monitoring in the railway and automotive industries.¹⁵⁶

Last, not least, cloud-based solutions for automatic analysis of measuring data are presented at the SENSOR+TEST. This is about a special kind of data mining or the extraction of metadata from a mass of measuring data. During the operation of a machine or plant, the system's software learns the normal signal pattern and creates a model. Any aberrations in the processes can thus be quickly identified.¹⁵⁷

Testing Technology

Where would sensor and measuring technology be without the means for testing? Testing technology is a discipline in its own right. Today's quality standards for products and production processes would never have been attained without it. On the other hand, testing technology in turn uses sensors and measurement to provide precise and reproducible results. Therefore, the SENSOR+TEST is exactly the right place to obtain information on the state of the art in testing technology and the details of diverse laboratory measuring devices.

Before the space probe BepiColombo of the European Space Agency (ESA) and the Japan Aerospace Exploration Agency (JAXA) gets underway to the largely unexplored planet Mercury this year, its solar generators have to submit to multichannel vibration tests. A supplier provides the required vibration control systems, mounted in two racks with 128 input channels each.¹⁵⁸

Climate chambers simulate realistic biological, chemical, and physical environmental conditions in scientific and industrial laboratories. As in the years before, suppliers of climate chambers are showing their latest developments at the SENSOR+TEST. This includes test chambers for temperature shocks, for instance. They operate with two chambers, one of which is heated up to +220 °C, the other cooled down to -80 °C. The alternating periods are less than 10 s, still enabling 1,000 alternations without defrosting. Based on a serially produced unit, one supplier developed a highly specialized solution for material tests of rechargeable and non-rechargeable batteries. Their service life and performance is determined by alternating temperature tests with a pulsating current.¹⁵⁹ Another specialty is a subassembly test chamber for the electrical and electronics industry. With a footprint of 1.3 m², the chamber has a capacity of 550 l. This enables temperature tests of -60 °C to +130 °C at quickly alternating speeds of 4.5 K/min (heating) or 3.3 K/min (cooling).^{160 161}

Stress analysis is essential for the electronics industry. The combined evaluation of temperature curves and images makes it possible to determine the exact point in time of a functional impairment of an individual component. A supplier of environmental technology is upgrading its testing technology in climate chambers to include time-controlled imaging. The patented solution allocates the images taken of a test piece by commercially available digital cameras, IR cameras, endoscopes, or microscopes to the correlating measuring values. This makes for a considerably more precise evaluation than that of the conventional "blind" test, while the simple use of the software remains the same.¹⁶²

A supplier of precision measuring technology has opened its range of stand-alone instruments for software applications. This allows better embedding of the devices into existing testbed environments or to integrate software features. For the first time, drivers and libraries are available for development tools, such as NI LabVIEW und DASyLab. Text-based programming languages are also supported.¹⁶³ A French supplier of material test stand has expanded the measuring range of his stand-alone tensile and compression test stand to 5 kN at travel deflections of 200 and 300 mm.¹⁶⁴ For greater forces of up to 50 kN, a bi-column material testing machine is available from the same supplier. Anyone who does not want to occupy oneself with the details of the tests and approvals will find qualified consultants at the SENSOR+TEST.

Electronic loads are used especially in testing power supply and control units, batteries, fuel and solar cells. With new, powerful 360-W or 400-W electronic loads, voltages up to 80 V or currents up to 80 A can be generated for testing power supplies in constant current, resistance, voltage, and power modes. In its low minimum operating mode, the load remains under 1 V at 40 A.¹⁶⁵

Automatic leakage and flow tests can be performed by small mains-powered desktop unit. Its main area of application is in leak testing of sample parts in the development and preproduction phase. The slipstream method used allows the real air leakage value to be displayed in Ncm³/min.¹⁶⁶

Components for Sensors and Measurement

There are a number of products especially designed for applications in sensor, measuring, and testing technology. With a time synchronization module, measurements of external measuring or automation systems can be synchronized beyond system boundaries with an accuracy better than 1µs. A number of output signals, such as DCF77, PPS, or Ethernet-based network protocols, are available for time synchronization.¹⁶⁷

Based on an open machine concept, a supplier is offering a multifunctional, modular micro-assembly system for microsensors. It offers a universal workspace of 1,200 x 700 mm. Sensor producers can integrate modules developed in-house or those of the manufacturer with a choice of 70 different expansion modules via power and communication interfaces on the portal system or on the baseplate of the basic machine. The production facility requires only a few setup steps and can assemble, laser-solder, and inspect.¹⁶⁸

Metal injection molding (MIM) is a relatively young technology. MIM can be used to reliably manufacture microcomponents with complex geometries, which are comparable to conventionally produced parts.¹⁶⁹

Calibration Systems

Complementing the vast spectrum of sensor, measuring, and testing technology, a broad range of calibration devices are also to be found at the SENSOR+TEST.

Flow-metering technology to date has hardly been standardized, which makes calibration of measuring devices expensive. Suppliers usually calibrate only their own flow meters. Independent, accredited calibration labs generally specialize in a single medium. Now, however, one enterprise is offering a manufacturer-independent calibration laboratory for flow meters for both groups of media, gases and liquids. The measuring methods are DAkkS approved according to DIN EN ISO 17025 and the measuring devices are calibrated with the greatest accuracy. The calibration measuring range extends from 1 ml/min to 16,000 l/min for gases and as of 1,000 l/min for liquids.¹⁷⁰

A specialist for measurement and control technology has maintained a DKD/DAkkS laboratory for temperature since 1992. Now, the enterprise has been accredited for on-site calibration of temperature sensors in the pharmaceutical, chemical, and food industries.¹⁷¹ Another enterprise offers to calibrate not only the temperature parameter, but also for density with respect to hydrometers with DAkkS accreditation.¹⁷² Calibrated measuring chains for air volume measurement are being shown by another enterprise. They comprise an LFE adapted to the measuring task and a long-term stable capacitive differential pressure gauge for volume flow measurement or a mass-flow sensor for standard liter signals. With this modular design, the manufacturer can calibrate and certify customized measuring chains in the calibration laboratory.¹⁷³ A flow specialist is offering a manufacturer-independent calibration service for flow meters and flow regulators. The gases, CO₂, He, N₂, Ar, air, CH₄ und H₂, in the range between 10 ml/min and 150 m³N/h can be calibrated by an accredited service.¹⁷⁴ Another exhibitor is presenting pressure calibrators for the range of very low differential pressures up to 200 bar overpressure in two accuracy classes.¹⁷⁵

Custom-tailored gas mixtures and standard gas mixtures as well as pure gases for verification and calibration of detectors and instruments are offered a manufacturer in pressurized cans of light aluminum. The offerings extend from simple UEG binary mixtures to laboratory standards with complex mixtures comprising a number of components with concentrations

in the ppm range. All gas mixtures are produced gravimetrically according to ISO6142 and have a mixture accuracy, optimal stability, and maximum durability.¹⁷⁶

Please note that this is only a small excerpt of the overall offerings at the SENSOR+TEST, as every specification of product properties implies the calibration of standards.

Conclusion

With about 550 exhibitors, the SENSOR+TEST is *the* measuring fair in Europe – with exhibitors from all over the world. Two conferences will be held parallel to the trade fair from 19 to 21 May 2015: the AMA Conferences SENSOR and the IRS² as well as two expert forums with presentations in Hall 11 and Hall 12, the Forum Innovative Testing, and on 19 May in Hall 12 the lecture forum on the special topic “Environmental Monitoring”. On all three days of the fair there will be live demonstrations and test drives offered by the suppliers of mobile measuring technology in the outdoor action area. And a further specialty are the theme stands “Vision Sensors and Systems” and a community stand supported by the BMW for young, innovative enterprises – a rich and varied offer from the Measurement Fair SENSOR+TEST.

For research by topics, products, applications as well as an overview of the many programs, there are offers on the Internet (www.sensor-test.com), for mobile handhelds (m.sensor-test.com) and the social media (www.facebook.com/sensorplustest, [twitter@sensorplustest](https://twitter.com/sensorplustest)). Follow the up-to-date information posted by the organizer and exhibitors during the fair on the Tweet wall in the reception area or with the hash tag #sensortest on Twitter.

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Press information on the SENSOR+TEST can be downloaded free of charge for journalists at www.sensor-test.com/press.

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- ¹ CiS Forschungsinstitut für Mikrosensorik und Photovoltaik GmbH, Erfurt, Germany
 - ² Nanjing Gaohua Technology Co. Ltd., Nanjing, China
 - ³ disynet GmbH, Brüggen, Germany
 - ⁴ disynet GmbH, Brüggen, Germany
 - ⁵ a.b.jödden gmbh, Krefeld, Germany
 - ⁶ Variohm EuroSensor Ltd., Towcester, Great Britain
 - ⁷ FemtoFiber Tec GmbH, Goslar, Germany
 - ⁸ Hochschule Mittweida, Mittweida, Germany
 - ⁹ Knowtion UG (haftungsbeschränkt), Karlsruhe, Germany
 - ¹⁰ IS-LINE GmbH, Unterschleißheim, Germany
 - ¹¹ SONTEC Sensorbau GmbH, Lennestadt, Germany
 - ¹² AMSYS GmbH & Co. KG, Mainz, Germany
 - ¹³ Kavlico GmbH, Minden, Germany
 - ¹⁴ Kistler Instrumente GmbH, Ostfildern, Germany
 - ¹⁵ Baoji Hengtong Electronics Co., Ltd., Baoji, Shaanxi, China
 - ¹⁶ Micro Sensor Co., Ltd, Baoji, Shaanxi, China
 - ¹⁷ Shanghai Holeader Measurement & Control Technology Co., Ltd., Shanghai, China
 - ¹⁸ Nanjing Gaohua Technology Co. Ltd., Nanjing, China
 - ¹⁹ Nanjing Wotian Technology Co. Ltd., Nanjing, China
 - ²⁰ Smartstone (Shanghai) Sensing & Control Tech Co., Ltd., Qingpu, Shanghai, China
 - ²¹ Xi'an Chinastar M&C Ltd., Xi'an, Shaanxi Province, China
 - ²² Pressure-Sensor.com, Newport News, Virginia, USA
 - ²³ Shanghai Holeader Measurement & Control Technology Co., Ltd., Shanghai, China
 - ²⁴ ZSE Electronic Mess-Systeme & Sensortechnik GmbH, Bietigheim-Bissingen, Germany
 - ²⁵ Nanolike - Nano Sensors, Ramonville-Saint-Agne, France
 - ²⁶ Micro Sensor Co., Ltd. Baoji, Shaanxi, China
 - ²⁷ Shanghai Holeader Measurement & Control Technology Co., Ltd., Shanghai, China
 - ²⁸ Variohm EuroSensor Ltd., Towcester, Great Britain
 - ²⁹ Fraunhofer-Institut für Silicatforschung ISC, Würzburg, Germany
 - ³⁰ Fraunhofer-Institut für Silicatforschung ISC, Würzburg, Germany
 - ³¹ disynet GmbH, Brüggen, Germany
 - ³² SI-special instruments GmbH, Nördlingen, Germany
 - ³³ SI-special instruments GmbH, Nördlingen, Germany
 - ³⁴ Xi'an Chinastar M&C Ltd, Xi'an, Shaanxi Province, China
 - ³⁵ Baoji Hengtong Electronics Co. Ltd., Baoji, Shaanxi, China
 - ³⁶ Nanjing Wotian Technology Co. Ltd., Nanjing, China
 - ³⁷ Micro Sensor Co., Ltd., Baoji, Shaanxi, China
 - ³⁸ CiS Forschungsinstitut für Mikrosensorik und Photovoltaik GmbH, Erfurt, Germany
 - ³⁹ pd²m, Darmstadt, Germany
 - ⁴⁰ ME-Meßsysteme GmbH, Hennigsdorf, Germany
 - ⁴¹ A.S.T. Angewandte System Technik GmbH, Dresden, Germany
 - ⁴² CSM Computer-Systeme-Messtechnik GmbH, Filderstadt, Germany
 - ⁴³ ZEMIC Europe B.V., Etten-Leur, Netherlands
 - ⁴⁴ Andilog Technologies, Vitrolles, France
 - ⁴⁵ Andilog Technologies, Vitrolles, France
 - ⁴⁶ Torque And More GmbH, Starnberg, Germany
 - ⁴⁷ disynet GmbH, Brüggen, Germany
 - ⁴⁸ disynet GmbH, Brüggen, Germany
 - ⁴⁹ disynet GmbH, Brüggen, Germany

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- 50 Quantitec GmbH, Hofheim a.Ts., Germany
 - 51 First Sensor AG, Berlin, Germany
 - 52 Quantitec GmbH, Hofheim a.Ts. , Germany
 - 53 disynet GmbH, Brüggen, Germany
 - 54 disynet GmbH, Brüggen, Germany
 - 55 OROS GmbH, Koblenz, Germany
 - 56 OROS GmbH, Koblenz, Germany
 - 57 OROS GmbH, Koblenz, Germany
 - 58 GeneSys Elektronik GmbH, Offenburg, Germany
 - 59 SI-special instruments GmbH, Nördlingen, Germany
 - 60 Sensirion AG, Stäfa, Switzerland
 - 61 Sensirion AG, Stäfa, Switzerland
 - 62 Sensirion AG, Stäfa, Switzerland
 - 63 JUMO GmbH & Co. KG, Fulda, Germany
 - 64 TC Mess- und Regeltechnik GmbH, Mönchengladbach, Germany
 - 65 Shanghai Holeader Measurement & Control Technology Co., Ltd., Shanghai, China
 - 66 Shanghai JNL Industry Co. Ltd., Shanghai, China
 - 67 Smartec B.V., Breda, Netherlands
 - 68 Ludwig Schneider GmbH & Co. KG, Wertheim, Germany
 - 69 EngineSens Motorsensor GmbH, Viernheim, Germany
 - 70 InfraTec GmbH Infrarotsensorik und Messtechnik, Dresden, Germany
 - 71 greenTEG AG, Zürich, Switzerland
 - 72 LumaSense Technologies GmbH, Frankfurt, Germany
 - 73 LumaSense Technologies GmbH, Frankfurt, Germany
 - 74 CSM GmbH Computer-Systeme-Messtechnik, Filderstadt, Germany
 - 75 GREATech GmbH, Mülheim a.d. Ruhr, Germany
 - 76 GREATech GmbH, Mülheim a.d. Ruhr, Germany
 - 77 rotronic messgeräte gmbh, Ettlingen, Germany
 - 78 Oriental System Technology Inc., Hsinchu, Taiwan
 - 79 DIAS Infrared GmbH, Dresden, Germany
 - 80 LumaSense Technologies GmbH, Frankfurt, Germany
 - 81 HEITRONICS Infrarot Messtechnik GmbH, Wiesbaden, Germany
 - 82 DIAS Infrared GmbH, Dresden, Germany
 - 83 LumaSense Technologies GmbH, Frankfurt, Germany
 - 84 AMSYS GmbH & Co. KG, Mainz, Germany
 - 85 Sensirion AG, Stäfa, Switzerland
 - 86 Korea Digital Co. Ltd., Guro-Gu, Seoul, Korea
 - 87 JUMO GmbH & Co. KG, Fulda, Germany
 - 88 AMSYS GmbH & Co. KG, Mainz, Germany
 - 89 rotronic messgeräte gmbh, Ettlingen, Germany
 - 90 greenTEG AG, Zürich, Switzerland
 - 91 Zentrum Mikroelektronik Dresden AG (ZMDI), Dresden, Germany
 - 92 LASER COMPONENTS GmbH, Olching, Germany
 - 93 LASER COMPONENTS GmbH, Olching, Germany
 - 94 Frankfurt Laser Company, Friedrichsdorf, Germany
 - 95 CODIXX AG, Barleben, Germany
 - 96 First Sensor AG, Berlin, Germany
 - 97 ET Enterprises Limited, Uxbridge, Great Britain
 - 98 Frankfurt Laser Company, Friedrichsdorf, Germany
 - 99 CiS Forschungsinstitut für Mikrosensorik und Photovoltaik GmbH, Erfurt, Germany

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- ¹⁰⁰ CiS Forschungsinstitut für Mikrosensorik und Photovoltaik GmbH, Erfurt, Germany
¹⁰¹ CMOSIS BVBA, Antwerpen, Netherlands
¹⁰² InfraTec GmbH, Infrarotsensorik und Messtechnik, Dresden, Germany
¹⁰³ Intenta GmbH, Chemnitz, Germany
¹⁰⁴ Measurement in Motion - Lehrstuhl VII, Universität Würzburg, Germany
Robotik und Telematik, Würzburg, Germany
¹⁰⁵ Dallmeier electronic GmbH & Co.KG, Regensburg, Germany
¹⁰⁶ Dallmeier electronic GmbH & Co.KG, Regensburg
¹⁰⁷ CiS Forschungsinstitut für Mikrosensorik und Photovoltaik GmbH, Erfurt, Germany
¹⁰⁸ LASER COMPONENTS GmbH, Olching, Germany
¹⁰⁹ Microflow Technologies BV, Arnhem, Netherlands
¹¹⁰ Microflow Technologies BV, Arnhem, Netherlands
¹¹¹ EngineSens Motorsensor GmbH, Viernheim, Germany
¹¹² PI Ceramic GmbH, Lederhose, Germany
¹¹³ PI Ceramic GmbH, Lederhose, Germany
¹¹⁴ Frankfurt Laser Company, Friedrichsdorf, Germany
¹¹⁵ Komyo Rikagaku Kogyo K.K., Kawasaki, Japan
¹¹⁶ Komyo Rikagaku Kogyo K.K., Kawasaki, Japan
¹¹⁷ SAXON Junkalor GmbH, Dessau-Roßlau, Germany
¹¹⁸ LumaSense Technologies GmbH, Frankfurt, Germany
¹¹⁹ Figaro Engineering Inc., Osaka, Japan
¹²⁰ First Sensor AG, Berlin, Germany
¹²¹ SITEX 45 SRL, Bukarest, Romania
¹²² SONTEC Sensorbau GmbH, Lennestadt, Germany
¹²³ PYREOS Ltd., Edinburgh, Great Britain
¹²⁴ JUMO GmbH & Co. KG, Fulda, Germany
¹²⁵ Oriental System Technology Inc., Hsinchu, Taiwan
¹²⁶ Figaro Engineering Inc., Osaka, Japan
¹²⁷ Vaisala Oyj, Vantaa, Finland
¹²⁸ Vaisala Oyj, Vantaa, Finland
¹²⁹ SITEX 45 SRL, Bukarest, Romania
¹³⁰ Data Translation GmbH, Bietigheim-Bissingen, Germany
¹³¹ Kistler Instrumente GmbH, Ostfildern, Germany
¹³² Softing Messen & Testen GmbH, Kirchentellinsfurt, Germany
¹³³ BMC Messsysteme GmbH (bmcm), Maisach, Germany
¹³⁴ Telemeter Electronic GmbH, Donauwörth, Germany
¹³⁵ Zentrum Mikroelektronik Dresden AG (ZMDI), Dresden, Germany
¹³⁶ Ahlborn Mess- und Regelungstechnik GmbH, Holzkirchen, Germany
¹³⁷ ALTHEN GmbH Mess- und Sensortechnik, Kelkheim, Germany
¹³⁸ Signal Concept GmbH, Markkleeberg, Germany
¹³⁹ Signal Concept GmbH, Markkleeberg, Germany
¹⁴⁰ ALLDAQ - a division of ALLNET GmbH, Germering, Germany
¹⁴¹ ALLDAQ - a division of ALLNET GmbH, Germering, Germany
¹⁴² Kistler Instrumente GmbH, Ostfildern, Germany
¹⁴³ Data Translation GmbH, Bietigheim-Bissingen, Germany
¹⁴⁴ Soundtec GmbH, Göttingen, Germany
¹⁴⁵ MagCam NV, Leuven, Belgium
¹⁴⁶ Zentrum Mikroelektronik Dresden AG (ZMDI), Dresden, Germany
¹⁴⁷ m+p international Mess- und Rechnerntechnik GmbH, Hannover, Germany
¹⁴⁸ BMC Messsysteme GmbH (bmcm), Maisach, Germany

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- 149 optiMEAS GmbH, Friedrichsdorf, Germany
 - 150 Quantitec GmbH, Hofheim a.Ts. , Germany
 - 151 Fraunhofer-Institut für Produktionstechnik und Automation IPA, Stuttgart, Germany
 - 152 IS-LINE GmbH, Unterschleißheim, Germany
 - 153 DELTA, Hørsholm, Denmark
 - 154 microsensys GmbH, Erfurt, Germany
 - 155 A.S.T. Angewandte System Technik GmbH, Dresden, Germany
 - 156 FARSENS S.L., Donostia - San Sebastián, Spain
 - 157 Knowtion UG (haftungsbeschränkt), Karlsruhe, Germany
 - 158 m+p international Mess- und Rechnertechnik GmbH, Hannover, Germany
 - 159 BINDER GmbH, Tuttlingen, Germany
 - 160 Weiss Umwelttechnik GmbH, Reiskirchen-Lindenstruth, Germany
 - 161 Vötsch Industrietechnik GmbH, Balingen-Frommern, Germany
 - 162 Weiss Umwelttechnik GmbH, Reiskirchen-Lindenstruth, Germany
 - 163 DEWETRON GmbH, Ostfildern, Germany
 - 164 Andilog Technologies, Vitrolles, France
 - 165 Telemeter Electronic GmbH, Donauwörth, Germany
 - 166 SI-special instruments GmbH, Nördlingen, Germany
 - 167 iba AG, Fürth, Germany
 - 168 Häcker Automation GmbH, Waltershausen/OT Schwarzgau, Germany
 - 169 OBE Ohnmacht & Baumgärtner GmbH & Co. KG, Ispringen, Germany
 - 170 Testo industrial services GmbH, Kirchzarten, Germany
 - 171 JUMO GmbH & Co. KG, Fulda, Germany
 - 172 Ludwig Schneider GmbH & Co. KG, Wertheim, Germany
 - 173 SI-special instruments GmbH, Nördlingen, Germany
 - 174 Wagner Mess- und Regeltechnik GmbH, Offenbach, Germany
 - 175 europascal GmbH, Hanau (Klein Auheim), Germany
 - 176 Air Products GmbH, Bochum, Germany