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I&M Technology at CERN

From the Editor's Bench

Mike Gard

The Remarkable I&M Technologies at CERN

The magazine you now hold is a celebration – a special issue highlighting the remarkable I&M technologies of CERN, the European Organization for Nuclear Research. I&M Magazine readers will know of CERN's existence and its importance to the world of high-energy physics. This issue is devoted to the technologies that make CERN work and enable studies at the true cutting edge of physics. In these pages are articles discussing technologies that will be familiar and exotic at the same time. We use data acquisition, but not tens of millions of channels at a time. We are aware of superconducting magnets; CERN has 27 km of them. The scope is huge. The I&M challenges are correspondingly huge, and the solutions will fascinate you.

This issue provides a forum for some of CERN's technology groups to share their remarkable work with us. The purpose of this brief editorial is to introduce the real architect of this issue: Dr. Pasquale Arpaia, the Guest Editor. Dr. Arpaia and his CERN colleagues have prepared a remarkable collection of tutorial articles. This issue exists because of Dr. Arpaia's persistence and effort. I hope you will join me in thanking Pasquale and his colleagues for the time and effort they have given to the magazine and to all of us.

More later,
Mike

Please contact Mike at IandMMagazineEIC@ieee.org.
His bio is available at http://www.ieee-ms.org.

Guest Editorial

Pasquale Arpaia

Instrumentation and Measurement Technologies for the CERN Large Hadron Collider

This Special Issue commemorates CERN's immense effort to construct the largest machine ever built by mankind: the Large Hadron Collider (LHC). The structural and technological complexity of the LHC is really remarkable. This single machine contains: an empty level space equal to one-tenth of the Moon's surface area, the second coldest place in the known universe (0.7 K lower than the average temperature of the universe), a magnetic field roughly 80,000 times greater than the Earth's, a length of superconducting wire strands equaling the Earth's orbit around the Sun, and data production during each experiment of about 1 Petabyte per second, i.e., a stack of 1.3 km of CDs. Two cathedrals full of electronics for the two major experiments of the LHC, ATLAS and CMS, are aligned to the magnet apertures for a beam transit controlled within a micrometer. In addition, all this technology was delivered at a cost equal to half of the total contracts of Italian soccer players over the same years of LHC construction.

The LHC experiments are the result of a coordinated effort of hundreds of labs worldwide, with multiple technologies that are not unique to CERN. To be precise, CERN has provided the locale and opportunity to catalyze a wide supranational community of researchers in engineering and experimental physics, each of whom has found in this ambitious project their own scientific purpose for more than a decade.

Mankind's largest machine is a measuring instrument. LHC is a precision multifunctional measurement machine unsurpassed in many of its key components. LHC has led us to the frontiers of a new physics after the Higgs boson discovery. In our Galilean approach, the horizons of new knowledge arise only at the frontiers of instrumentation and measurement technology.

Moreover, the largest machine ever built by humans is not an instrument for war, nor economic profit, but of knowledge. This powerful tool is aimed at basic research, i.e. it has a cultural purpose. The LHC is a machine to rethink such basic concepts as the structure of matter, mass, and the composition of the universe. This new frontier of technology is not available to individuals or even nations, not even the most visionary or wealthiest, wishing to reduce technological research to mere product innovation and private market-driven development. For all of these reasons, we accepted an invitation to realize a Special Issue on the "Instrumentation and Measurement Technologies for the CERN Large Hadron Collider" for the I&M Magazine.

The first tutorial of the Special Issue arises from **ATLAS (A Toroidal LHC Apparatus)**, the largest physics experiment at LHC. Measuring 46 m long, 25 m high and 25 m wide, the 7000 metric-ton ATLAS detector is the largest volume particle detector ever constructed. More than 3000 scientists from 174 institutes in 38 countries work on the ATLAS experiment to investigate a wide range of physics, from the search for the Higgs boson to extra dimensions and particles that could make up dark matter. Particle beams collide at the center of the ATLAS detector, making collision debris in the form of new particles which fly out from the collision point in all directions. Six different detecting subsystems arranged in layers around the collision point record the paths, momentum, and energy of the particles, allowing them to be individually identified. A huge magnet system bends the paths of charged particles so that their momenta can be measured. The paper written by Philippe Farthouat goes through the architecture choices for the most important parts of the detector, as well as some specific developments in analog and digital signal processing.

The second tutorial concerns **LHCb (LHC beauty experiment)**, which is set up to explore what happened after the Big Bang to allow matter to survive and build the universe we inhabit today. The LHCb's mission is to record the decay of particles containing *b* and anti-*b* quarks, collectively known as B mesons. The experiment's 4500 metric-ton detector is specifically designed to filter out these particles and the products of their decay. About 670 scientists representing 65 different universities and laboratories (including five associated institutions) from sixteen countries are involved in the project, with support from about 250 technicians and engineers. The authoritative paper of its spokesperson, Pierluigi Campana, provides meaningful insight not only into the detector and data processing technologies for the LHCb experiment but also its main physics.

Another paper comes out from the **most recent, smallest, but smart experiment of LHC: UA9**. The UA9 experimental equipment was installed in March 2009, in anticipation of future ultra-high luminosity operation. This experiment will assess the use of bent silicon crystals as primary collimators to coherently direct the beam halo onto the secondary absorber, thus reducing out-scattering, beam losses in critical regions, and radiation load. Note that the energy in the two LHC beams is sufficient to melt almost one ton of copper! Particles with reduced energy or nuclear debris are prone to depart from stable orbits in the dispersive area of the accelerator, thus producing radiation damage in such sensitive devices as the superconducting magnets. The tutorial of UA9's spokesperson, Walter Scandale, describes how UA9 detectors produced

unprecedented evidence of this beneficial crystal-based collimation by highlighting the method used to measure the reduced flux of nuclear debris generated by channeled particles.

The Sources, Targets, and Interactions Group led by Roberto Losito studies particle generation and interception and other beam interactions with matter. The paper by Alessandro Masi reports research of the Section of Equipment Controls and Electronics to provide **low-uncertainty position transducers for the LHC Collimators**. Achieving measurement uncertainty of a few micrometers over a measurement range of tens of mm is extremely challenging in the LHC environment. The collimators experience a high level of ionizing radiation on the order of MGy/year; thus, no electronics can be embedded in the sensors which must be radiation resistant. Radiation-safe alcoves for electronics can be one km removed from the collimator itself, reducing the signal–to-noise ratio at the conditioning electronics input, and presenting a complex matching problem because of the cable length. Moreover, some collimators are affected by interfering magnetic fields produced by nearby high current cables.

Indisputably, one of most important I&M technologies in particle accelerators is beam instrumentation. Rhodri Jones is leader of the **Beam Instrumentation Group** within Paul Collier's Beams Department. Beam instruments are the *ears* and *eyes* of the accelerator, and they provide the unique way *watch* the beam, by allowing its properties and quality to be characterized. Rhodri's tutorial describes the exceptional metrological and technological challenges of measuring the LHC's beam position with a resolution better than ten micrometers, at a rate of up to 40 MHz and a dynamic range from 1 bunch of ~2×109 charges to 2808 bunches of ~2×1011 charges, using ultrahigh vacuum sensors operating near 2 K, with the requirement for radiation tolerant electronics located up to 3 km from the sensors.

The LHC doubled worldwide superconducting technology production during its construction. Amalia Ballarino's Superconducting Cables and Devices Section, inside the Magnets, Superconductors, and Cryostats (MSC) Group led by Luca Bottura, is developing new I&M technologies for superconducting applications. Co-authored by Giuseppe Montenero, Ballarino's paper reports recent advancements in the measurement of *critical current*, the capacity of a device to carry electrical current and a key design parameter for any large-scale superconductivity application.

Superconduction requires effective measurement of the cryogenic temperature. LHC superconducting magnet temperature measurements are used in feedback closed control loops to

adjust the cooling power; thus, measurement uncertainty has a direct impact on the temperature control range that must be as wide as possible to maintain operating conditions that allow particle beams to circulate around the LHC accelerator. Measurement uncertainty results from the intrinsic quality of the temperature sensor, the conditioning electronics, and the calibration; the **LHC design target was ± 0.01 K in the range 1.6 to 2.2 K**. The paper by Juan Casas of the MSC Group's Cryolab & Instrumentation Section shows how the LHC requirements were satisfied for more than 5000 cryogenic temperature sensors operating in a high radiation environment.

According to the opinion of LHC project Leader Lyn Evans, **power conversion and the metrology for its quality assessment**, is one key factor for LHC achievement. Individual LHC sector currents must be controlled with very high accuracy in amplitude and time to ensure that the beam of particles sees the same magnetic field in all sectors of the machine: ± 5 ppm of tracking among all sectors and better than ± 2 ppm of short term stability at 13 kA. Miguel Cerqueira Bastos, head of the High Precision Measurements Section of Jean Paul Burnet's Electronic Power Converters Group, describes the technical choices and compromises made in the design, evaluation, integration, and operation of the current transducers and ADCs at the heart of the current measurement chain of the LHC main power converters.

This Issue cannot highlight all of the impressive I&M technologies of the LHC machine. It is our hope that this modest insight will reveal the most important result of LHC: the experiences and enthusiasm that motivated all of the authors during these years of hard work. This **enthusiasm** also infected the **reviewers** of the papers of this Issue, whom we warmly thank for their patience and professionalism: Francisco Alegria, Aldo Baccigalupi, Salvo Baglio, Matteo Bertocco, Luca Bottura, Mauro D'Arco, Alessandro Danisi, Luca De Vito, Steve Dyer, Kim Fowler, Nicola Giaquinto, Pedro Girao, Francesco La Monaca, Philippe Lebrun, Giuseppe Iacobucci, Claudio Narduzzi, Roberto Ottoboni, Nicola Pasquino, Pedro Ramos, Mario Savino, Rosario Schiano lo Moriello, Ezio Todesco, and Wendy Van Moer.

Feature Articles

Signal Conditioning and Digitization for the ATLAS Experiment: Tutorial 46

Philippe Farthouat

ATLAS (A Toroidal LHC Apparatus) is one of four main experiments at the Large Hadron Collider (LHC). ATLAS was designed as a general-purpose detector studying proton-proton interactions happening in its center. This paper deals with the architecture choices, as well as some of the most interesting developments in analog and digital signal processing for the most important sub-detectors. The large number of channels involved, the very harsh environment of the front-end electronics, the timing constraints, and the large amount of data to be handled have been of primary importance. The availability of suitable ASIC technologies and the capacity of the collaboration to do efficient designs have been key enablers for the front-end processing, while the use of high-speed optical links and of high-performance FPGAs have been instrumental for the data transmission and processing.

This summary includes text from the article.

Detector and Data Processing Technologies for the LHCb Experiment: Tutorial 47

Pierluigi Campana

The Large Hadron Collider beauty (LHCb) experiment at the LHC has been designed and built to search for signs of new physics phenomena beyond the Standard Model of particle physics (*pp*) in the decays of heavy particles made of beauty and charm quarks, created in proton-proton collisions. This article presents the main components of the detector including: the vertex locator which identifies the primary vertices generated by the *pp* collisions and the secondary ones produced by short-lived particles; an identification system based on the use of Cherenkov light technique whose presence determines the type of particle; a magnet that bends particles in the XZ plane; three tracking planes located before and after the magnet that measure the particle trajectories; a calorimeter system in which photons, electrons, and hadrons are absorbed and identified; and an instrumented iron filter to select muons.

This summary includes text from the article.

The UA9 Experiment on Crystal-Assisted Collimation at the CERN-Super Proton Synchrotron: Tutorial 48

Walter Scandale

Channeling is the phenomenon constraining the path of a charged particle in a crystalline solid. High-energy charged particles can be captured in channeling states by the electromagnetic potential of the atomic planes in a crystal, thus performing quasi-harmonic oscillations between them. Particles channeled in a bent crystal are deflected by the bend angle. This provides a powerful method to steer particle beams. The UA9 Collaboration investigates how tiny bent crystals could assist and improve the collimation process in the Large Hadron Collider (LHC) at CERN in view of future ultra-high luminosity operation. This tutorial describes the main features of UA9 and the method used to measure the reduced flux of nuclear debris produced by channeled particles.

This summary includes text from the article.

Low Uncertainty Position Transducers for the LHC Collimators: Tutorial 49

Alessandro Masi, Alessandro Danisi, and Roberto Losito

The Equipment, Controls, and Electronics section in the EN/STI Group at CERN (ECE) is responsible for the positioning control of movable beam intercepting devices (e.g., scrapers, collimators, shielding, and targets) in hard radioactive environments within a few micrometers of accuracy. It provides solutions for radiation-hard electronic devices, and it is characterized by a strong R&D activity on harsh environment electromagnetic linear position sensing and their related conditioning electronics. This tutorial focuses on the low-uncertainty linear position sensor solutions developed for the LHC collimators. The aim is to give an overview of the harsh environment where the position sensors operate and present the most advanced solutions. Particular attention is given to the performance of the sensors with external interfering magnetic fields and to the reading techniques. In addition, attention focuses on the main uncertainty sources.

This summary includes text from the article.

Beam Instrumentation Systems of the Large Hadron Collider: Tutorial 50

Owain Rhodri Jones

The Large Hadron Collider (LHC) is equipped with a whole suite of beam instrumentation, including the beam loss system designed to address the danger of catastrophic damage from an uncontrolled loss of particles and avoid excessive heating of the superconducting magnets used to guide the beams. Beam losses can occur due to equipment failure, beam instability or operator error. This tutorial presents an overview of the system employed to measure: the beam position, beam losses; fast beam aborts if the losses become unacceptably high; the beam intensity to know how many particles are being accelerated at any given time; and the transverse and longitudinal size and shape of the beam which are indicators of the beam quality. The other system covered in this tutorial is used to measure the distribution of particles around the LHC ring.

This summary includes text from the article.

Transformer-based Measurement of Critical Currents in Superconducting Cables: Tutorial 51

Amalia Ballarino, Giuseppe Montenero, and Pasquale Arpaia

This tutorial introduces the reader to available state-of-the-art CERN solutions for the metrological improvement of cable test stations based on a superconducting transformer employed at the Facility for the Research of Superconducting Cables (FReSCa). The issues related to monitoring a superconducting transformer and to measuring the transformer's secondary current have been experienced as having primary relevance. Attention is focused on the design and implementation of a fully digital monitoring system for the superconducting transformer. Results from the system validation (carrying out critical current assessments) at the FReSCa test station highlight the high performance of the system with respect to the reference setup and also the compatibility of the measurement results between the two systems.

This summary includes text from the article.

LHC Thermometry: Laboratory Precision on an Industrial Scale in a Hostile Environment: Tutorial 52

Juan Casas

The measurement of cryogenic temperatures is essential for operating large-scale cryogenic

installations and in experimental set-ups used for understanding low temperature physics phenomena. This tutorial presents how the CERN's Large Hadron Collider (LHC) requirements for measurement of cryogenic temperatures were met and addresses the challenge of a temperature uncertainty of ±0.01 K in the range 1.8 K to 2.2 K that takes into account the background radiation field provoked by the LHC circulating proton beams, the sheer quantity of the measuring channels and an operational lifetime of at least 20 years. The LHC superconducting magnets' temperature measurements are used in feedback closed control loops to adjust the cooling power; thus, the measurement uncertainty has a direct impact on the width of the temperature control range that shall be as wide as possible to increase the availability of appropriate operation conditions for permitting the circulation of particle beams around the LHC accelerator.

This summary includes text from the article.

High Accuracy Current Measurement in the Main Power Converters of the Large Hadron Collider: Tutorial 53

Miguel Cerqueira Bastos, Gunnar Fernqvist, Gregory Hudson, John Pett, Andrea Cantone, Francis Power, Alfredo Saab, Björn Halvarsson, and John Pickering

In the Large Hadron Collider (LHC) at CERN, the powering of the main dipole and quadrupole circuits is divided into eight separate powering subsectors due to the very high magnetic energy stored in these circuits and to protection constraints of the superconducting magnets. As a consequence, individual sector currents must be controlled with very high accuracy in amplitude and time to ensure that the beam of particles sees the same magnetic field in all sectors. This results in a requirement for current tracking between the different sectors of better than ± 5 part-per-million (ppm) and short-term stability of better than ± 2 ppm, at 13 kA currents. The LHC power converters are current sources employing digital control to ensure a given reference function to the magnet current. This tutorial describes the main aspects of the ADC and current transducer design, evaluation and integration in the LHC main power converters.

This summary includes text from the article.

Departments

New Products

Robert Goldberg

Configurable Automated Test Set

Aeroflex Incorporated announces the release of the Aeroflex 7215 Configurable Automated Test Set. The 7215 is a complete radio test system designed for production and depot-level testing of military and software-defined radios (SDR). The standard 7215 configuration includes a high-resolution touch-screen user interface, RF testing up to 2.6 GHz, 90 MHz of instantaneous bandwidth for both digital signal generation and analysis, and multiple RF and audio instruments in a single package.

Advanced digital signal analysis tools, such as EVM measurements and even power dropout tests on frequency-hopped waveforms, are optional and are custom developed for each customer's unique test requirements. Customers who require automation for RF and non-RF radio tests can also use the 7215 as a smaller, more capable and cost-effective alternative to large rack and stack ATE systems.

Aeroflex claims that the 7215 features accuracy and specifications comparable to stand-alone instruments. Typical specifications include:

- DC to 2.6 GHz Frequency Coverage,
- 90 MHz Instantaneous Bandwidth for Signal Generation and Digitization,
- Phase Noise of -102 dBc/Hz,
- RF Generator Level accuracy of +/-1.0 dB, and
- -147 dBm DANL Spectrum Analyzer with 85 dB Dynamic Range.
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Aeroflex 7215 pricing and delivery information is available by contacting your local Aeroflex sales office or sending an email to info-test@aeroflex.com.

Portable Maintenance Aid

EADS North America Test and Services introduces its Portable Maintenance Aid, PMA-2100, a flexible maintenance tool and automated test platform housed in a single, rugged instrument chassis. The PMA-2100 provides the functionality of multiple, general-purpose instruments in one small, self-contained system, thereby reducing the type and amount of equipment required by deployed or field support teams. The portability of the PMA-2100 simplifies maintenance and repair logistics by enabling both on-site and field shop maintenance.

This rugged, durable test equipment provides multiple test instruments, including stimulus and measurement, driven by a common operating system. With the addition of industry standard test automation software, user-developed software, or software developed by EADS North America Test and Services, the PMA-2100 can be set up to configure the stimulus, make selected measurements, and report the status (Go or No Go) to the technician as well as automatically record, store and communicate the results. Furthermore, the technician can control the desired instrument functionality to make manual measurements, run and manage automated test routines, and monitor the test results.

Instrumentation functions are integrated utilizing Synthetic Instruments (SIs) and ATE concepts into a standard Windows™ operating system tablet. The SI environment allows the product to adapt to different applications and provides unparalleled instrument flexibility. By integrating the SIs with the computer, the PMA-2100 allows the instrumentation to seamlessly integrate with the maintenance data collection system and to automate the maintenance functions themselves.

Leveraging the full capabilities of a ruggedized Windows ™ 7 computer, the PMA-2100 can easily store and access user manuals and other documentation for the Units Under Test (UUTs). The technician can also contact a supervisor or engineer via the embedded Wi-Fi to report results in real time from a remote location.

The PMA-2100 can be utilized in a wide variety of applications, such as at-platform testing of avionics, fire control, weapons, communications, navigation, displays and processors. In addition, it can be used as a memory loader/verifier of on-board electronics and processors along with many other applications.

Find more information at www.eadsnorthamerica.com.

Bench-top Performance in a Pocket-sized Scope

Pico Technology has released a new range of PicoScope 2000 Series oscilloscopes that occupy about the area of a passport and are only 19 mm (three-quarters of an inch) thick. Connected to and powered from a USB port, they offer bandwidths up to 200 MHz and feature an arbitrary waveform generator yet are almost 80% smaller than the previous generation of PicoScopes. This makes them ideal scopes for engineers on the move to keep in their laptop bag, while offering all the features and performance of a traditional bench-top oscilloscope.

The specifications include a maximum sampling rate of 1 GS/s, adjustable analog offset over the full input range, and high-speed USB streaming up to 1 MS/s for waveform captures of up to 100 million samples in length. The built-in signal source can act as a standard signal generator (sine, square, triangle and others) with programmable sweep or as a 12 bit 20 MS/s full-function arbitrary waveform generator.

Despite their small size, the dual channel scopes include a comprehensive list of features as standard including an FFT spectrum analyzer, up to 48K samples of segmented memory for rapid captures, math channels, automatic measurements, color persistence display mode, advanced digital triggering, mask limit testing and serial decoding. A free SDK with example code is available for developing your own applications in languages such as C, Microsoft Visual Basic®, National Instruments LabVIEW® and MathWorks MATLAB®.

The new PicoScope 2000 Series oscilloscopes are available from Pico distributors worldwide and from www.picotech.com.

Fully Automated Inline In-Circuit Test Solution

Agilent Technologies introduces the fully automated Medalist i3070 Series 5i Inline In-Circuit Test System. With a compact chassis, the system uses 33 percent less floor space than conventional 070 systems.

Designed to SMEMA specifications, the i3070 Series 5i seamlessly integrates into high-volume production lines. This minimizes the need for operator handling, thereby saving labor costs, reducing the risk of product damage due to electrostatic discharge, and improving product quality.

The system features Agilent's innovative short wire fixturing technology to ensure transportability, repeatability, and stability of tests. The ergonomic design allows users to easily change fixtures and perform routine maintenance. The i3070 Series 5i retains all of Agilent's ICT technologies such as Cover-Extend Technology and a comprehensive suite of boundary-scan technologies. Forward compatibility of standard test programs ensures ease of switching from offline to inline testing.

For more information, please visit http://www.agilent.com. A system preview is available at www.agilent.com/find/i3070inline_video.

Software Supports 3D PCB Design

Altium Limited announces the new version of its flagship product, Altium Designer 14. The new Altium Designer 14 extends the company's position in native 3D PCB Design systems by delivering a new customer-centric platform with heavy emphasis on core PCB design technologies. Altium Designer now features support for flex and rigid-flex design, including schematic capture, 3D PCB layout, analysis and programmable design – all in a single, unified solution.

With its unique native 3D visual support of this technology, Altium Designer 14 supports new innovations in electronic design by allowing for increased processing and communication within a smaller, more fluid space. The enhanced platform allows for smaller packaging of electronic designs, which in turn leads to lower cost of materials and production, and increased durability.

Advanced board design capabilities are accessible to mainstream designers for Flex and Rigid Flex PCB design support. This release includes the ability to handle the challenges of flex and rigid-flex designs including advanced layer stack management. Also featured is support for embedded PCB components, allowing far greater design miniaturization opportunities by placing standard components on an inner layer of the circuit board during fabrication.

A full overview of Altium Designer 14 can be found at www.altium.com/en/products/altium-designer/features.

Mini Hand-Held Light Meter

Anaheim Scientific has introduced the first model in its new M-Series of mini handheld Environmental meters: the M110 Mini Light Meter. The M-Series makes taking measurements out in the field easy and convenient. The M110 – Mini Light Meter Characteristics
Features:

- Light Source: Fluorescent, metal halide, high-pressure sodium and incandescent,
- Lux Range: 400, 4000, 40000, 400000,
- Foot-candle Range: 40, 400, 4000, 40000, and
- Accuracy: ±3% ±3 Lux (0~500 Lux), ±3% (above 501 Lux).

The M-Series meters have the following features in common:

- Large 3¾ digit display,
- Small 5.3 x 1.9 x 0.2 in size (16.5 x 4.8 x 0.5 cm) and weight of only 2.8 oz (80 grams),
- Data hold,
- Maximum/Average/Minimum Hold,
- Zero adjustment,
- Low battery indicator,
- Auto power off and disable function,
- Light weight (less than 9 oz.), and
- Powered by 2 x AAA batteries.

For additional technical information and specifications, visit the Model M110 Product Page at http://anaheimscientific.com/products/light-meters/M110-mini-light-meter.html.

Multichannel Thermocouple Data Logger

Onset announces the HOBOUX120 Thermocouple Logger, a four-channel LCD data logger for measuring and recording temperature in a broad range of monitoring applications. The compact HOBO UX120 Thermocouple Logger offers a price/performance advantage over competitive products by combining a full-featured, deployment-friendly LCD display and flexible support for a variety of plug-in thermocouple probes.

The new logger makes it easy and convenient to record temperatures over a broad range (-260 to 1820 °C) and can accept up to four J, K, T, E, R, S, B, or N type probes. This flexibility enables the logger to be used in a range of monitoring projects. In addition to accepting four thermocouple sensors, the logger features an internal temperature sensor for logging ambient temperatures, further extending the range of application possibilities.

The HOBO UX120 Thermocouple Logger streamlines temperature monitoring applications in a number of ways. For example, it features an easy-to-view LCD that visually confirms logger operation and battery status, eliminating the need to connect the logger to a computer to view the information. As the logger records temperatures, the LCD refreshes every 15 seconds to provide a near real-time readout of current temperatures as well as minimum, maximum, average, and standard deviation statistics. On-screen alarms can be set for each temperature channel to notify users if temperatures exceed high or low thresholds.

The logger also features a large memory capacity capable of storing 1.9 million measurements. This enables the loggers to be deployed for longer periods between offloads. Firmware is user upgradeable, and the logger offers start, stop, and restart pushbuttons to make installation fast and easy.

Once data has been recorded with the HOBO UX120 Thermocouple Logger, it can be easily viewed in graph form and analyzed using Onset's HOBOware® Pro software. Time-saving tools allow users to batch-configure and readout dozens of loggers in a fraction of the time it would take with previous generations. The software also features a Bulk Export tool that allows users to export data files to text format for use in spreadsheets.

Please visit http://www.onsetcomp.com/products/data-loggers/ux120-014m for complete details and technical specifications.

AC/DC Millivolt Data Logger with Current Clamp Input

CAS Data Loggers and Lascar introduce an affordable new ac and dc Millivolt Data Logger compatible with ac and dc current clamps. Featuring a current clamp input and 4mm banana plug inputs, the logger's USB interface enables quick setup and data download. When used with a current clamp, the new data logger measures and stores up to 127,232 ac and dc current readings over a 0 to 1000-amp dc measurement range (0 to 723 amps for ac). In Energy Monitoring mode, this data is converted into power, cumulative energy (using a user-defined voltage value) and cumulative cost (using a user-supplied energy unit cost). The logger's ac and dc millivolt measurement mode allows for direct measurement of voltage up to 1-Vdc (700 mVac).

The high contrast 4-digit LCD shows a variety of current, power, energy, and cost information. At the touch of a button, users can cycle between the most recent, maximum and minimum measurement values. The LCD also displays battery status, alarm indicators, and measurement units. Users can choose among immediate, delayed, and push-to-start logging modes, and it is easy to configure custom alarm thresholds. Users can set logging rates anywhere between once a second and once every twelve hours.

The Lascar data logger will not lose its stored readings when the battery is discharged or replaced. The meter's USB interface makes it easy to configure the logger. Free EasyLog USB control software is also supplied with each data logger. The software uses an intuitive wizard format to guide the user through setup of the data logger and subsequent download of collected

data. The user can easily set up the logger and view the collected data by just plugging the data logger into a PC's USB port. After downloading the data, users can graph, print, and export stored data to other applications such as Excel.

For more information on the new AC/DC Millivolt Data Logger, visit the website at www.DataLoggerInc.com.

Handheld Spectrophotometer

X-Rite, Incorporated has announced its next generation of handheld sphere spectrophotometers to help companies with their color quality, formulation and monitoring programs by improving color consistency, reducing production costs of complex materials and tracing measurements cross multiple locations.

The Ci6x family of scalable solutions is able to read a wide range of materials and provide benchmark measurements that can be used at each step of the production or assembly process. The Ci6x is X-Rite's response to customers' needs for a versatile handheld spectrophotometer that provides tighter controls of color for materials, in-process parts and finished goods along with an audit trail to ensure productivity for facilities with multiple sites. The Ci64UV product is equipped with UV illumination to support the growing trend of adding optical brightener agents to materials.

With NetProfiler 3.0 enabled, the Ci6x allows companies to optimize and verify that their instruments are calibrated to a single centerline standard. NetProfiler 3.0 ensures that color measurements taken throughout the supply chain are accurate and reliable. By simplifying and automating an audit trail, brands and manufacturing plants can monitor compliance at any facility.

The Ci6x key handheld features include:

- A Spectralon sphere for enhanced durability providing years of reliable measurements;
- Embedded NetProfiler 3 delivers operations managers the confidence to share, validate and audit data from device to device;
- Simultaneous specular included/specular excluded measurement in less than 2 seconds provides quick response quality control to determine if color variance is caused by appearance;
- USB and available Bluetooth communications capabilities for easy connection to computers and remote measurement devices;

- Ci64 Graphical Jobs™ use visuals on a large color screen to ensure reliable measurement collection, reducing human error and creating consistency in processes;
- Aperture sizes 4, 8 and 14 mm diameters are available for customized measurement;
- Compatible with X-Rite SP6x handheld historical data, making data transfer and sharing easy; and
- Seamless integration with other powerful X-Rite software for industrial applications.

For more detailed product information on Ci6x, visit www.xrite.com/Ci6x.

Signal and Spectrum Analyzer Covers Up to 67 GHz

Rohde & Schwarz presents the R&S FSW67, a new high-end signal and spectrum analyzer with unique features: a frequency range up to 67 GHz to 67 GHz with integrated preamplifier and an analysis bandwidth to 320 MHz. The device supports developers in demanding measurement tasks in the microwave range for aerospace and defense applications or for wireless communication.

The new model of high-end signal and spectrum analyzer, R&S FSW67 covers the frequency range from 2 Hz to 67 GHz in a single sweep. Since no external harmonic mixer and consequently no complicated wiring is required, the R&S FSW67 simplifies the test setup. The mirror and other side receptions caused by the harmonic mixing can be suppressed.

Thanks to its unique analysis bandwidth up to 320 MHz, the R&S FSW67 also measures broadband, hop and end chirp signals. Users can now easily perform spectral measurements and modulation measurements in the 60 GHz band. Therefore, the device is not only for development, test, verification and manufacture of transmitters and components for radar applications, satellite and military communications systems. The R&S FSW67 also supports development tasks for fast wireless connections such as WiGig (IEEE 802.11ad) or WirelessHD.

The integrated, multi-standard radio analyzer function makes it possible to measure spectrum and modulation parameters of differently modulated signals simultaneously and to analyze their time reference. This allows very efficient analysis of how and why different signals affect each other. Users can run multiple applications on different measurements and the multi-view feature on the screen simultaneously.

Find more information at http://rohde-schwarz.com.

Compact Photoelectric Sensors Provide Reliable Detection for High-Volume Installations

Banner Engineering introduces its next-generation S18-2 compact photoelectric sensor series. These self-contained, DC-operated sensors provide an economical sensing solution for cost-sensitive and high-volume installations. Built with advanced ASIC (Application Specific Integrated Circuit) technology, the diffuse mode S18-2 sensors are resistant to fluorescent light and offer a high level of crosstalk avoidance.

Banner S18-2 sensors feature a powerful and bright visible red emitter beam that reaches up to 25 meters (82 feet), which allows for easy alignment and set-up. For ease of use, the S18-2 sensors also offer a highly visible output, and dual-function power and stability indicators. The indicators are comprised of one green and two yellow LED lights. Solid green indicates power is applied and the sensor is ready, while green flashing specifies a marginal sensing signal. The two bright yellow LEDs, visible from both sides of the sensor, indicate the output is conducting.

The S18-2 sensors are well sealed against water ingress. A wide operating temperature range of -40 to +70 °C ensures optimal performance for diverse applications.

Learn more about the S18-2 photoelectric sensors by visiting www.bannerengineering.com.

RFID with UHF Read/Write Head

TURCK introduces the Q175 compact UHF read/write head, the latest addition to the company's comprehensive RFID portfolio. Designed to communicate with multiple data carriers, the Q175 employs both HF (High Frequency) and UHF (Ultra High Frequency) RFID technologies. This capability allows TURCK to expand its RFID technology to accommodate diverse industrial production and logistic processes.

Featuring a ready-to-deploy design, the active read/write head supports the ISO 18000-6C and EPCglobal Gen 2 Standards and can be easily integrated into existing production lines. For optimal use in harsh applications, the Q175 combines its antenna and electronics in a robust IP67 aluminum housing. It also allows direct mounting on metal and can be utilized at high temperatures or in autoclaves. The Q175 UHF read/write head can be operated on TURCK's modular and block BL ident® RFID systems simultaneously with HF components.

For more information, please visit http://www.turck.com.

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