CAL LAB

THE INTERNATIONAL JOURNAL OF METROLOGY

Uncertainty Considerations for Gas Flow Rate Reference Measurement Systems

Manual/Automated Decade Resistance Using Microcontroller Technique

Metrology for a Competitive Advantage

2010
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CAL LAB
THE INTERNATIONAL JOURNAL OF METROLOGY

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FEATURES

DEPARTMENTS

ON THE COVER: Author Hakan Kaykisizli of Tubitak Ulusal Metroloji Enstitusu (UME), the National Metrology Institute of Turkey, with gas flow measurement system. (See article page 23)

CONFERENCES & MEETINGS 2010

Jul 12-16 Coordinate Metrology Systems Conference. The CMSC is the only North American conference dedicated solely to users of portable, high-precision measurement technology used to inspect manufactured and assembled components on the factory floor. www.cmsc.org

Jul 25-29 NCSL International Conference. Providence, RI. Technical session, tutorials, industry committee meetings. Topics: metrology education, workplace and professional development, international developments and programs, measurement uncertainty, new instrumentation. Industry exhibitors. www.ncsli.org

Aug 31 - Sep 2 High Resolution X-ray and CT Symposium for High-Resolution Micro- and Nanofocus Computed Tomography. Wunstorf (near Hanover), Germany. GE Sensing & Inspection Technologies GmbH, tel +49 5031 172-0, fax +49 5031 172-299, phoenix-info@ge.com, www.phoenix-xray.com.

Sep 13-17 AUTOTESTCON. Orlando, FL. IEEE sponsored conference on automatic test equipment and systems readiness, lab management. Industry exhibitors. www.autotestcon.com.

Oct 12-14 VII Controlling, Analyzing and Measuring Equipment. Russia, Moscow. http://www.kipexpo.ru/english/.

Oct 12-14 Microtechnology Expo. Russia, Moscow. www.microtechexpo.ru/eng/.

Oct 25-28 IEST Fall Conference. Arlington Heights, IL. Includes working group sessions as well as a variety of tutorials covering issues related to cleanrooms and controlled environments. www.iest.org

Oct 26-28 28th International North Sea Flow Measurement Workshop. St Andrews, UK. Technical papers for the 2010 Workshop are invited from operators, regulators, engineering contractors, service companies and research organisations about their flow measurement experience. This workshop will provide a variety to opportunities for sharing information through technical presentations, real work experiences, poster presentations and networking sessions. TUV NEL Ltd., tel +44 (0)1355 272858, events@tuvnel.com, www.tuvnel.com.

Oct 31 - Nov 5 25th ASPE Annual Meeting. Atlanta, GA. American Society for Precision Engineering (ASPE), www.aspe.net.

Nov 15-18 Eastern Analytical Symposium and Exposition (EAS). Somerset, NJ. www.eas.org.

Dec 10-12 2nd India Lab Expo. New Delhi, India. Scientific, biotechnology, analytical & laboratory technology. Exhibition of new products and latest innovation. www.indialabexpo.com.

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EDITOR'S DESK

Article Correction: In the Jan-Feb-Mar 2010 issue of *Cal Lab* author Roman Honig contributed "Practical Aspects of High Resistance Measurements." In the section: Two-Terminal Resistance Standard with Metal Shield Additonal Split Guard and Auxiliary Resistance Between Guard Parts (e.g. Ohm Labs), Mr. Honig stated "The guard parts are connected using an auxiliary resistor of high value (R_{aux}=100MΩ). Mr. Honig would like to correct this statement to: "The auxiliary resistor connecting two parts of the split guard on the Ohm Labs resistors is not fixed at 100 MΩ value, but it equals the nominal value of the standard resistor. Therefore it can be used with a passive guard source for any combination of resistance standards and create appropriate guard voltage."

World Metrology Day

This year in reflecting on what to say about World Metrology Day, I decided to play "devil's advocate" and ask myself what is so important about having a World Metrology Day? For those who don't know about World Metrology Day, it is held on May 20, the day in 1875 when the Treaty of the Metre was signed in Paris, France. The treaty created the International Bureau of Weights and Measures or Bureau International des Poids et Mesures (BIPM) as it is called in French. On that day in 1875, the representatives of 17 countries agreed with their signatures that international commerce could be better facilitated if measurements to define products, such as weight, length and volume could be agreed upon for products moving across national borders.

Our more recent embrace of the importance of that day was initiated by BIPM Director Andrew J. Wallard in 2005 when he urged the now 54 members of the BIPM to celebrate World Metrology Day worldwide. More than 80 countries joined in the festivities this year with events such as national lab "open days" with speeches and lab tours and metrology symposiums, and one would hope tasty cakes in the shape of the metre bar (but that is unconfirmed as of this writing.)

So World Metrology Day is now enjoyed around the world. But why is it important and what purpose is there in bringing attention to a hundred-year-old treaty? It's important to celebrate the day because normally metrology is a quiet activity conducted in the bowels of some company or laboratory and even fellow employees aren't aware of its function; and because metrology is still unknown to pretty much most citizens of every country in the world, and as such, all countries now have trouble recruiting young people to enter the profession. Our ranks are diminishing as more and more metrologists reach retirement age and for the most part companies must hire untrained technicians or degreed professionals from other fields and train them because there are so few universities and technical trade schools with metrology programs. If we can raise the visibility of the field of metrology, we can attract more people to the profession and we can convince schools to offer metrology programs.

Finally, this year's theme for World Metrology Day was "A Bridge to Innovation." The BIPM poster featured the Great Belt East Bridge in Storebæltsbroen, Denmark. Each of the bridge's 55 prefabricated, 48-metre, 500-ton bridge sections were measured in detail in order to adjust the four hangers which carry the section, to ensure the correct tension. The measured and expected deviations from the theoretical measurements required a hanger adjustment of ±30 mm. The adjustment of each hanger pin was determined to an accuracy of ±1 mm. Contractors and subcontractors from 10 European countries were involved in building the bridge from 1988 to 1997 — and it worked! And that's what's important about metrology — metrology makes innovation and cooperation across national borders possible!

Metrology rocks!

Carol Singer

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CONFERENCES & MEETINGS 2011

Mar 31-Apr 1 METROMEET: 7th International Conference on Industrial Dimensional Metrology. Bilbao, Spain. Topics: digital and optical developments; new European and international rules and methods to improve industrial processes and productivity; advances of micro- and nanometrology; measurement issues of large work pieces; metrology and economics; virtual metrology; software; multi-sensor coordinate metrology; accreditation and certification; future metrology trends; metrology education; in-line inspection; uncertainty, traceability and reliability of measurements. www.metromeet.org, tel +34 94 480 51 83, info@metromeet.org. Deadline for presentation proposals 31st July 2010. www.metromeet.org/en/metromeet/call.php.

May 24-27 AUSPLAS, AUSTECH and National Manufacturing Week. Melbourne, Australia. info@exhibitionmanagement.com, www.ausplas.com.

Aug 21-25 NCSLI Conference. National Harbor, MD. Conference theme: 50 Years: Reflecting On The Past - Looking To The Future. www.ncsli.org.

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Dimensional Metrology, Physical Metrology, CCT Exam, Assessment/Audits, Measurement & Calibration, Measurement Uncertainty, SPC. J&G Technology, tel 952-935-1108, gmeyer@jg-technology.com, www.jg-technology.com.

Dimensional Measurement, Measurement Uncertainty, Measurement & Calibration. The QC Group, tel 800-959-0632, training@theQCgroup.com.

SEMINARS Australia and New Zealand

Aug 11 Calibration of Weights and Balances. Lindfield, NSW, Australia. National Measurement Institute, Australia, www.measurement.gov.au/Services/Training/Pages/default.aspx.

Aug 11 Pressure Calibration. Lower Hutt, New Zealand. Measurement Standards Laboratory of New Zealand, http://msl.irl.cri.nz/training-and-resources/training-courses.

Aug 12 Density Measurement. Lower Hutt, New Zealand. Measurement Standards Laboratory of New Zealand, http://msl.irl.cri.nz/training-and-resources/training-courses.

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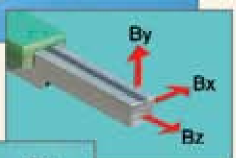
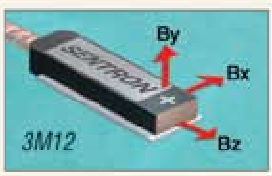


3RTP

YM12



3M12

Application	Product	Range	Resolution	Bandwidth
Linear field sensing. Non-contact measurement of position, angle, vibration, current. Small size, low power.	CSA-1V 1-axis Hall IC, SOIC-8	± 5mT	~ 10µT	dc to 100kHz
	2SA-10 2-axis Hall IC, SOIC-8	± 40mT	~ 50µT	dc to 10kHz
High sensitivity and accuracy for low fields. Survey and monitor sites for magnetically sensitive equipment.	MAG-01 1-axis Fluxgate Teslameter	± 2mT	± 0.1nT	dc to 10Hz
	MAG-03 3-axis Fluxgate Transducer	± 1mT	± 0.1nT	dc to 3kHz
Linear field measurement. Feedback control. Quality control. Magnet mapping. Unique 3-axis at one point.	YM12 1-axis Hall Transducer	± 2T	± 12µT	dc to 5kHz
	3M12 3-axis Hall Transducer	± 2T	± 20µT	dc to 1kHz
	3RTP 3-axis Hall Transducer	± 2T	± 100µT	dc to 10kHz
Hand-held 3-axis for fringe field mapping, quality control, safety monitoring.	7025 3-axis Hall Teslameter	± 2T	± 10µT	dc
Precision field measurement and control. Laboratory and process magnets. Analytical instruments.	DTM-133 1-axis Hall Teslameter	± 3T	± 5µT	dc to 10Hz
	DTM-151 1-axis Hall Teslameter	± 3T	± 0.1µT	dc to 3Hz
Calibration of magnetic standards and sensors. Very high resolution and long-term stability.	2026 total field NMR Teslameter	0.04 to 20T	± 0.1µT	dc
	FW101 total field NMR Teslameter	1.4µT to 2.1T	± 0.5nT	dc
Precision flux change measurement.	PDI 5025 Digital Voltage Integrator	40 V.s	± 2E-8V.s	1ms to 2^{15}ms

Conversion of magnetic flux density (B) tesla to gauss: 0.1nT = 1µG, 100µT = 1G, 1T = 10kG

Electric Current (isolated measurement)

867-400

CT-36

Application	Product	Range	Resolution	Bandwidth
High sensitivity for low currents, currents at high voltage, differential currents.	IPCT Current Transducer	± 5A	± 10µA	dc to 4kHz
Linear sensor for low-noise, high accuracy, high stability power supplies or amplifiers.	867-400 Current Transducer	± 400A	< 4ppm	dc to 100kHz
	866-600 Current Transducer	± 600A	< 4ppm	dc to 100kHz
Instruments for development, quality control, calibration, precision power measurement.	860R Current Transducer	to ± 2000A	< 5ppm	dc to 300kHz
	862R Current Transducer	to ± 25kA	< 5ppm	dc to 10kHz
	866R 6-channel Current Transducer	to ± 600A	< 10ppm	dc to 100kHz
Passive current transformer for rf and pulse current. Low loss, high frequency.	CT Current Transformer	to ± 10kA	to 5V/A into 50 ohm	to 2GHz
	ICT Charge Transformer	to ± 400nC	± 0.5pC	1µs to <1ps

Fiber-Optic I/O

FTR

CNA

Application	Product	Range	Resolution	Bandwidth
Input/Output modules that can be placed locally at the transducer or controlled unit. For high voltage, high noise environments, RF signal transmission.	FTR RS-232-C link			50 to 40 kB
	CNA Digital & Analog link	± 100mV to ± 10V	16-bit	dc to 30Hz
	p2p Digital & Analog link	- 20dBm to + 20dBm	< 25dB for 0dBm	dc to 3GHz

Aug 13 Infrared Radiation Thermometry. Lower Hutt, New Zealand. Measurement Standards Laboratory of New Zealand, http://msl.irl.cri.nz/training-and-resources/training-courses.

Aug 17 Balances and Weighing Workshop. Lower Hutt, New Zealand. Measurement Standards Laboratory of New Zealand, http://msl.irl.cri.nz/training-and-resources/training-courses.

Aug 17 Spectrophotometer Calibration. Lower Hutt, New Zealand. Measurement Standards Laboratory of New Zealand, http://msl.irl.cri.nz/training-and-resources/training-courses.

Aug 18 Measurement, Uncertainty and Calibration. Lower Hutt, New Zealand. Measurement Standards Laboratory of New Zealand, http://msl.irl.cri.nz/training-and-resources/training-courses.

Aug 19 Temperature Measurement and Calibration. Lower Hutt, New Zealand. Measurement Standards Laboratory of New Zealand, http://msl.irl.cri.nz/training-and-resources/training-courses.

Aug 20 Humidity Workshop. Lower Hutt, New Zealand. Measurement Standards Laboratory of New Zealand, http://msl.irl.cri.nz/training-and-resources/training-courses.

Aug 24 Balances and Weighing Workshop. Auckland, New Zealand. Measurement Standards Laboratory of New Zealand, http://msl.irl.cri.nz/training-and-resources/training-courses.

Aug 24-25 Traceable Electrical Energy Metering. Lower Hutt, New Zealand. Measurement Standards Laboratory of New Zealand, http://msl.irl.cri.nz/training-and-resources/training-courses.

Aug 25 Measurement, Uncertainty and Calibration. Auckland, New Zealand. Measurement Standards Laboratory of New Zealand, http://msl.irl.cri.nz/training-and-resources/training-courses.

SEMINARS Europe & United Kingdom

Sep 24-26 Flow Measurement and Calibration: Liquid and Gas. Munich, Germany. In English. (Held during Oktoberfest). TrigasFI GmbH, tel: +49-8165-64 72 0, info@trigasfi.com, http://www.trigasfi.de/html/en_seminars.htm.

Sep 27-29 Durchflussmessung und Kalibrierung. Munich, Germany. In Deutscher Sprache. TrigasFI GmbH, tel: +49-8165-64 72 0, info@trigasfi.com, http://www.trigasfi.de/html/en_seminars.htm.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Jul 15-16 Auditing to ISO 17205. Bloomington/Burnsville, MN. J&G Technology, tel 952-935-1108, gmeyer@jg-technology.com, www.jg-technology.com/seminars.html.

Oct 28-29 Auditing to ISO 17205. Bloomington/Burnsville, MN. J&G Technology, tel 952-935-1108, gmeyer@jg-technology.com, www.jg-technology.com/seminars.html.

SEMINARS: Analytical Chemistry

Nov 15 Metrology in the Analytical Laboratory. Somerset, NJ. Stranaska LLC, www.stranaska.com. www.eas.org.

SEMINARS: Certified Calibration Technician Exam

Sep 13-17 CCT-501 Metrology for Cal Lab Personnel (CCT Prep). Seattle, WA. Fluke, tel 888-79-FLUKE, www.fluke.com/2010caltraining.

Sep 21 Calculator Refresher for Certification Exams. Bloomington/Burnsville, MN. J&G Technology, tel 952-935-1108, gmeyer@jg-technology.com, www.jg-technology.com/seminars.html.

Nov 2 Calculator Refresher for Certification Exams. Bloomington/Burnsville, MN. J&G Technology, tel 952-935-1108, gmeyer@jg-technology.com, www.jg-technology.com/seminars.html.

Nov 3-5 CCT Preparation. Bloomington/Burnsville, MN. J&G Technology, tel 952-935-1108, gmeyer@jg-technology.com, www.jg-technology.com/seminars.html.

Nov 3-5 CCT Review. Minneapolis, MN. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

Nov 10-12 CCT Review. Schaumburg, IL. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

SEMINARS: Dimensional and Gage Calibration

Jul 29-30 GD&T Training - Fundamentals. Minneapolis, MN. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

Jul 12-13 Calibration Training and Hands-On Gage Repair. Blaine, MN. IICT Training & Productions, info@consultinginstitute.net, http://consultinginstitute.net/.

Jul 13-14 Basic Dimensional Measurement Tools and Methods. Minneapolis, MN. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

Jul 13-15 Coordinate Measuring Machine Training. Minneapolis, MN. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

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Jul 15-16 Calibration Training and Hands-On Gage Repair. Bloomington, MN. IICT Training & Productions, info@consultinginstitute.net, http://consultinginstitute.net/.

Jul 20-21 Calibration Training and Hands-On Gage Repair. Detroit, MI. IICT Training & Productions, info@consultinginstitute.net, http://consultinginstitute.net/.

Jul 22-23 Calibration Training and Hands-On Gage Repair. Toledo, OH. IICT Training & Productions, info@consultinginstitute.net, http://consultinginstitute.net/.

Jul 22-23 Basic Dimensional Measurement Tools and Methods. Orange County, CA. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

Jul 29 GD&T Management Overview. Minneapolis, MN. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

Aug 3 GD&T Management Overview. Orange County, CA. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

Aug 3-4 GD&T Training - Fundamentals. Orange County, CA. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

Aug 9-10 GD&T Training - Fundamentals. Warsaw, IN. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

Aug 10-11 Calibration Training and Hands-On Gage Repair. Colorado Springs, CO. IICT Training & Productions, info@consultinginstitute.net, http://consultinginstitute.net/.

Aug 11-13 GD&T Training - Advanced Concepts. Warsaw, IN. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

Aug 12-13 Calibration Training and Hands-On Gage Repair. Boulder, CO. IICT Training & Productions, info@consultinginstitute.net, http://consultinginstitute.net/.

Aug 12-13 GD&T Training - Advanced Concepts. Minneapolis, MN. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

Aug 16-18 Basic Dimensional Metrology. Bloomington/Burnsville, MN. J&G Technology, tel 952-935-1108, gmeyer@jg-technology.com, www.jg-technology.com/seminars.html.

Aug 17-18 GD&T Training - Fundamentals. Canton, OH. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

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Aug 17-18 Basic Dimensional Measurement Tools and Methods. Canton, OH. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

Aug 19 GD&T Management Overview. Canton, OH. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

Aug 19-20 GD&T Training - Fundamentals. Canton, OH. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

Aug 26-27 Basic Dimensional Measurement Tools and Methods. Jackson, MS. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

Aug 30-31 Calibration Training and Hands-On Gage Repair. Richmond, VA. IICT Training & Productions, info@consultinginstitute.net, http://consultinginstitute.net/.

Aug 31 GD&T Management Overview. Orlando, FL. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

Aug 31 - Sep 1 GD&T Training - Fundamentals. Orlando, FL. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

Aug 31 - Sep 2 Coordinate Measuring Machine Training. Minneapolis, MN. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

Sep 2-3 Calibration Training and Hands-On Gage Repair. Myrtle Beach, SC. IICT Training & Productions, info@consultinginstitute.net, http://consultinginstitute.net/.

Sep 13-14 GD&T Training - Fundamentals. Rolling Meadows, IL. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

Sep 14-15 Basic Dimensional Measurement Tools and Methods. Schaumburg, IL. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

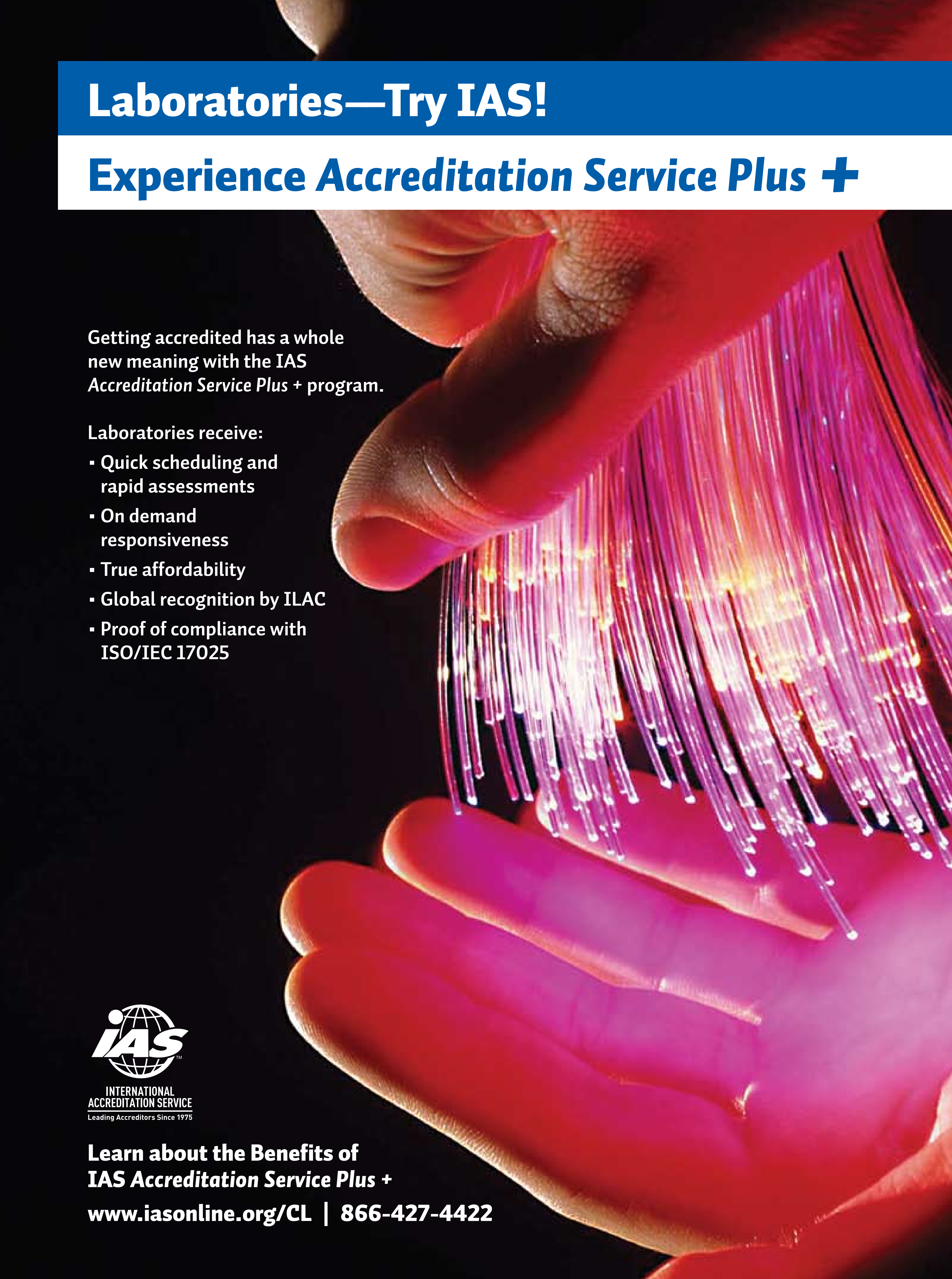
Sep 14-15 Calibration Training and Hands-On Gage Repair. Schaumburg, IL. IICT Training & Productions, info@consultinginstitute.net, http://consultinginstitute.net/.

Sep 15-17 GD&T Training - Advanced Concepts. Rolling Meadows, IL. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

Sep 16-17 Calibration Training and Hands-On Gage Repair. Kenosha, WI. IICT Training & Productions, info@consultinginstitute.net, http://consultinginstitute.net/.

Sep 23 GD&T Management Overview. Jackson, MS. The QC Group, tel 800-959-0632, www.theqcgroup.com/courselist/.

Sep 23-24 GD&T Training - Fundamentals. Jackson, MS. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.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SEMINARS: Flow

Sep 27-30 Gas Flow Calibration Using molbloc/molbox. Phoenix, AZ. Fluke - DH Instruments, tel 888-79-FLUKE, www.fluke.com/2010caltraining.

Nov 15-18 Gas Flow Calibration Using molbloc/molbox. Phoenix, AZ. Fluke - DH Instruments, tel 888-79-FLUKE, www.fluke.com/2010caltraining.

SEMINARS: General Metrology, Calibration Training & Laboratory Management

Aug 9 Measurement & Calibration Overview. Bloomington/Burnsville, MN. J&G Technology, tel 952-935-1108, gmeyer@jg-technology.com, www.jg-technology.com/seminars.html.

Aug 17-19 MET-302 Hands-On Metrology Statistics. Seattle, WA. Fluke, tel 888-79-FLUKE, www.fluke.com/2010caltraining.

Aug 9-12 MET-301 Advanced Hands-On Metrology. Seattle, WA. Fluke, tel 888-79-FLUKE, www.fluke.com/2010caltraining.

Sep 20-24 CLM-301 Cal Lab Management for the 21st Century. Seattle, WA. Fluke, tel 888-79-FLUKE, www.fluke.com/2010caltraining.

Sep 27-30 MET-101 Basic Hands-On Metrology. Seattle, WA. Fluke, tel 888-79-FLUKE, www.fluke.com/2010caltraining.

Nov 1-4 MET-301 Advanced Hands-On Metrology. Seattle, WA. Fluke, tel 888-79-FLUKE, www.fluke.com/2010caltraining.

SEMINARS: Measurement Uncertainty

Jul 13-15 Measurement Uncertainty Workshop. Fenton, MI. Presented by QUAMETEC Institute, tel 810-225-8588, www.QIMTonline.com.

Aug 5 Measurement Uncertainty Overview. Minneapolis, MN. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

Aug 5-6 Measurement Uncertainty Budgets. Minneapolis, MN. The QC Group, tel 800-959-0632, Training@theQCgroup.com, www.theqcgroup.com/courselist/.

Aug 5-6 Understanding Measurement Uncertainty. Bloomington/Burnsville, MN. J&G Technology, tel 952-935-1108, gmeyer@jg-technology.com, www.jg-technology.com/seminars.html.

Sep 14-16 Measurement Uncertainty Workshop. Fenton, MI. Presented by QUAMETEC Institute, tel 810-225-8588, www.QIMTonline.com.

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Sep 23-24 Pipette Quality Management Certification. Westbrook, ME. ARTEL, tel 888-406-3463, tel 207-854-0860, info@artel-usa.com, www.artel-usa.com/news/training.aspx.

Nov 15-16 Pipette Quality Management Certification. Westbrook, ME. ARTEL, tel 888-406-3463, tel 207-854-0860, info@artel-usa.com, www.artel-usa.com.

SEMINARS: Pressure

Sep 13-17 Precision Pressure Calibration. Phoenix, AZ. Fluke - DH Instruments, tel 888-79-FLUKE, www.fluke.com/2010caltraining.

Oct 12-15 Setting Up and Using COMPASS® for Pressure Software. Phoenix, AZ. Fluke - DH Instruments, tel 888-79-FLUKE, www.fluke.com/2010caltraining.

Dec 6-10 Precision Pressure Calibration. Phoenix, AZ. Fluke - DH Instruments, tel 888-79-FLUKE, www.fluke.com/2010caltraining.

SEMINARS: Software

Oct 4-7 MET/CAL Database and Reports. Seattle, WA. Fluke, tel 888-79-FLUKE, www.fluke.com/2010caltraining.

Oct 11-14 MET/CAL Procedure Writing. Seattle, WA. Fluke, tel 888-79-FLUKE, www.fluke.com/2010caltraining.

Oct 18-21 MET/CAL Advanced Programming Techniques. Seattle, WA. Fluke, tel 888-79-FLUKE, www.fluke.com/2010caltraining.

SEMINARS: Temperature

Aug 2-3 Principles of Temperature Metrology. American Fork, UT. Fluke - Hart Scientific, tel 888-79-FLUKE, www.fluke.com/2010caltraining.

Aug 4-5 Advanced Topics in Temperature Metrology. American Fork, UT. Fluke - Hart Scientific, tel 888-79-FLUKE, www.fluke.com/2010caltraining.

SEMINARS: Vibration / Shock

Sep 20-23 Fundamentals of Random Vibration and Shock Testing, HALT, ESS, HASS. San Jose, CA. Equipment Reliability Institute, tel 805-564-1260, tustin@equipment-reliability.com, http://equipment-reliability.com/open_courses.html.

Oct 12-14 Pyrotechnic Shock Testing, Measurement, Analysis and Calibration. Santa Clarita, CA. Equipment Reliability Institute, tel 805-564-1260, tustin@equipment-reliability.com, http://equipment-reliability.com/open_courses.html.

Nov 1-4 Fundamentals of Random Vibration and Shock Testing, HALT, ESS, HASS. Orlando, FL. Equipment Reliability Institute, tel 805-564-1260, tustin@equipment-reliability.com, http://equipment-reliability.com/open_courses.html.

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Fluke Receives $1.4 Million Stimulus Funding for Smart Grid Calibration

Fluke Corporation, the global leader in handheld electronic test and measurement technology and electrical calibration, will receive $1.4 million in federal stimulus funding made possible by the American Recovery and Reinvestment Act, to ensure the Smart Grid is reliable and stable, and ready to accept power from renewable resources including wind and solar. The funding is to be applied to developing a new calibration technology creating a standard for evaluating electricity flowing into the electric power Smart Grid. The standard will enable consistent measurement of electricity from all sources, including renewable resources such as wind and solar. The grant was awarded by the U.S. Commerce Department's National Institute of Standards and Technology (NIST) in the area of Measurement Science and Engineering Research to support research in areas deemed of critical national importance.

Fluke's new calibration technology will be used to calibrate Phasor Measurement Units (PMUs), a gating technology that measures the health of the electrical power grid. PMUs play a vital role in the deployment of the Smart Grid, by measuring and evaluating power flowing into the grid from increasingly diverse sources. Grid distribution centers use this critical information to determine where and when to send power across transmission lines, leading to more efficient use of energy and lessening the risk of power interruptions and outages. PMUs identify the preconditions that lead to power interruptions.

According to a recent study at Lawrence Berkeley National Laboratory, power interruptions cost the U.S. economy about $79 billion annually, or about one third of what the nation spends on electricity. Add to this the need for the Smart Grid to carry energy from renewable sources, and there is an even higher potential for future conflicts to occur, putting the U.S. Smart Grid at risk for power interruptions.

NIST received over 1,300 proposals for the Recovery and Reinvestment Act grants and Fluke was one of only 27 companies awarded grants in the area of measurement science and engineering research. Fluke will develop the calibrator over the next 26 months and, as part of the grant, will invest $390,000 of its own money in the development effort.

Vaisala Acquires Veriteq Instruments

Vaisala, a global leader in environmental and industrial measurement, has strengthened its position in the life science market through the strategic acquisition of Veriteq Instruments Inc., a continuous monitoring system and data logger company based in Canada. Veriteq is a leading provider of productized continuous monitoring systems and data logger solutions for the life science industry comprised

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Symmetricom's 5071A Primary Reference Standard

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Symmetricom's XLi Time and Frequency System

The XLi is a modular time and frequency system with an embedded high performance GPS receiver. This system enables precision time and frequency measurements that are traceable to UTC. Depending on the configuration, the XLi can provide:

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of pharmaceutical, biotechnological and medical device companies. The company employs approximately 40 persons and it is located in Vancouver, Canada.

The global life science industry is strictly regulated by international and national authorities. In order to protect their high value goods and to comply with regulations, companies need to monitor and control the conditions of their critical environments such as cleanrooms, laboratories and warehouses. Life science is the focus area for Vaisala's controlled environments business, and the acquisition of Veriteq, with its life science emphasis, aligns perfectly with Vaisala's strategy.

Vaisala manufactures a comprehensive range of innovative observation and measurement products and services for meteorology, weather critical operations and controlled environments. Headquartered in Finland, Vaisala employs over 1400 worldwide and is listed on the Nordic Stock Exchange, Helsinki. www.vaisala.com

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Argonne National Laboratory Dedicates New Scanning Probe Microscopy Building

The Center for Nanoscale Materials (CNM) at the U.S. Department of Energy's (DOE) Argonne National Laboratory has dedicated a new scanning probe microscopy building. The new building will house a recently developed scanning probe microscope that measures spin-polarized electrons on surfaces.

Nanomagnetism research using the LT-SPM may lead to more energy-efficient motors, advanced information storage, processing prototype devices, advanced medical therapy and biomagnetic sensing concepts. The LT-SPM is a multi-functional scanning probe microscope developed for the high-resolution properties of spin-polarized surfaces at high magnetic fields (9 T) and low temperatures (4.2 K). This state-of-the-art instrument expands the CNM programs in nanomagnetism and nanoferroelectrics. With spin-polarized capabilities and the ability to characterize insulating samples, this instrument will propel the CNM to the forefront of science using scanning probes to pursue fundamental materials research.

A new building was constructed adjacent to the CNM to house the LT-SPM, which requires a highly stable operating environment that is free of acoustic and vibratory interference. The microscope also produces relatively large stray magnetic fields that are incompatible with instruments in the CNM, which was designed specifically to be free of magnetic fields.

The Center for Nanoscale Materials at Argonne National Laboratory is one of five DOE Nanoscale Science Research Centers (NSRCs), premier national user facilities for interdisciplinary research at the nanoscale level, supported by the DOE Office of Science. Together the NSRCs comprise a suite of complementary facilities that provide researchers with state-of-the-art capabilities to fabricate, process, characterize and model nanoscale materials, and constitute the largest infrastructure investment of the National Nanotechnology Initiative. The NSRCs are located at DOE's Argonne, Brookhaven, Lawrence Berkeley, Oak Ridge and Sandia and Los Alamos national laboratories. For more information about the DOE NSRCs, visit http://nano.energy.gov.

Veriteq Offers Guide to FDA Criticism Form 483 Letters

"How to Avoid and Respond to Public FDA Criticisms—Form 483 Letters—for Temperature, Humidity and other Controlled Environments" is now available from Veriteq, a leader in FDA-compliant environmental monitoring, alarming, reporting and temperature/humidity technology. The 10-step Guide is designed to help pharmaceutical processors, blood and tissue banks, clinical laboratories, medical device manufacturers, research hospitals, and other GxP facilities who receive warning letters respond quickly and appropriately within the permitted 15-day window. Proper FDA 483 letter response is critical to both help in reputation repair and for real remediation actions to assure a quality process and patient safety.

FDA 483 letters are expected to increase this year, reflecting the FDA's recent staff expansion and rewrite of the FDA 483 letter rules to narrow response time to the new 15-day window.

If a company receives a warning letter it is a matter of public record listed on the FDA's web site. Veriteq's guide will help quality departments that have received such public criticism regroup, but more importantly, will give some best-practice tips that will help FDA-regulated organizations avoid warning letters in the first place.

The guide can be obtained at www.veriteq.com/fda_response.htm or contact Janice Bennett, Veriteq Marketing Manager, 800-683-8374 or +1-604-273-6850 outside North America), fax 604-273-2874.

Fluke Acquires Ruska, Pressurements from GE Sensing

Fluke Corporation has announced that it has acquired the Ruska and Pressurements businesses from GE's Sensing & Inspection Technologies division. Ruska and Pressurements will be integrated into the Fluke Calibration organization, which is a global leader in metrology and calibration products and services for electrical, temperature, pressure, and flow measurements.

"We are excited to welcome Ruska and Pressurements to the Fluke family," said Barbara Hulit, Fluke president. "Our product lines complement each other, with the Ruska and Pressurements piston gauges and pressure controllers expanding our existing offering."

Ruska, founded in 1944, is a leading global manufacturer of precision laboratory instrumentation, offering highly accurate primary pressure standards, transfer standards, and air data test sets. Ruska also offers calibration services for virtually any pressure device. Pressurements products, originally from Pressurements, Ltd in the UK, provide a comprehensive range of instruments for the accurate measurement of pressure including hydraulic deadweight testers and combined pressure and vacuum deadweight testers.

Agilent, Tabor Electronics Announce OEM Agreement

Agilent Technologies Inc. and Tabor Electronics Ltd. today announced an OEM agreement establishing Tabor as a provider of Agilent test solutions for the high-speed arbitrary waveform generator (AWG) market. An integral aspect of this OEM agreement is the all-new Agilent 81180A, a 4.2GSa/s Arbitrary Waveform Generator that delivers exceptionally high dynamic range.

Established in 1971, Tabor Electronics has become a world-leading source of high-end test and measurement equipment. Tabor has earned global recognition for its highly skilled workforce and innovative engineering capabilities. In addition to offering a full range of self-branded instruments, Tabor is also a world-class OEM that private-labels a variety of products for industry leaders.

Tabor's extensive product portfolio includes pulse, function and arbitrary waveform generators, high-voltage amplifiers, waveform and modulation creation software and more in various platforms, interfaces and frequency ranges. For more information visit www.taborelec.com or www.agilent.com.

Uncertainty Considerations for Gas Flow Rate Reference Measurement Systems

Hakan Kaykisizli, Vahit Ciftci, Ilker Meral
TUBITAK UME, National Metrology Institute of Turkey

Gas flow rate measurement devices are usually calibrated in secondary flow laboratories and the lower level measurement standards are conducted to the traceability chain by the primary or national measurement standards which are established and maintained at the national metrology institutes of that country. Since the SI unit for gas flow rate is derived from the meter and the second, the uncertainty related to a reference system is expected to come from the dimensional and time calibration of that standard. Reference systems implementing the principle of combined gas law like a PVTt system (pressure-volume-temperature-time) does not obey this generalization and pressure-temperature measurements play an active role in uncertainty calculations. A system that utilizes the method of weighing the collected gas in a vessel offers an advantage over volumetric methods since there is no need for density corrections. Either it is a gravimetric or volumetric standard, to reach the lowest uncertainty possible is one of the important flow standard design considerations. In this paper the effects of design and operation of the bell prover, piston, PVTt and gravimetric systems are discussed with results of their relevant overall uncertainty.

1. Introduction

National metrology institutes and secondary laboratories that deal with gas flow rate measurement choose the bell prover, piston prover, PVTt system (pressure-volume-temperature-time) and gravimetric reference standards, theoretically and experimentally best examined, as top of their traceability chain. Some designs are commercially available in the market but some are the subject of research and development in metrology institutes. Every reference standard has been established to give an accurate indication of flow rate with the minimum uncertainty that can be reached by using the primary standards which are the direct realization of SI units.

In the case of flow, the SI units meter, seconds, Kelvin, kilogram and the derived unit Pascal are the subject of interest [1]. Flow rate indication of a reference system is defined as a function of the variables in (1) and the total uncertainty of a measurement system having a number of independent individual uncertainties is the square root of the sum of the squares of all the error contributions [2] as shown by formula (2).

$$Q = f(a,b,c...) \tag{1}$$

$$U = \sqrt{\left\{\left(\left(\frac{\partial f}{\partial a}\right)_{b,c} u(a)\right)^2 + \left(\left(\frac{\partial f}{\partial b}\right)_{a,c} u(b)\right)^2 + \left(\left(\frac{\partial f}{\partial c}\right)_{a,b} u(c)\right)^2 + ...\right\}_{a,b,c}} \tag{2}$$

The question then becomes which parameters most effect the total uncertainty of a reference system and what to do for a lower uncertainty. To discuss the uncertainty considerations for flow rate measurement references one can group the systems in their major categories, namely, displaced volume systems (bell prover, piston prover), constant-volume sytems (PVTt) and direct weighing systems.

Previously conducted uncertainty analysis of these systems by metrology institutes has shown that the dimensional measurements and dynamic parameters like pressure and temperature are the dominant parameters in the uncertainty calculations when compared with the effects like thermal expansion, surface roughness, etc. In the next section uncertainties that are evaluated by statistical analysis of experimental data are discussed for the mentioned flow rate measurement reference systems.

2. Flow Rate Measurement Systems

2.1 Displaced Volume Systems

2.1.1 Bell Prover

A bell prover system works on the principle of translating the displaced volume of a gas to a linear movement of a bell. Achievement of constant pressure and temperature throughout a stroke of the bell, compensation for buoyancy, surface tension and friction effects are considered as important parameters for a successful design. Bell Prover systems can operate in two ways, either data collection during emptying the bell or vice versa, depending on the design. Data collection during the bell filling method is

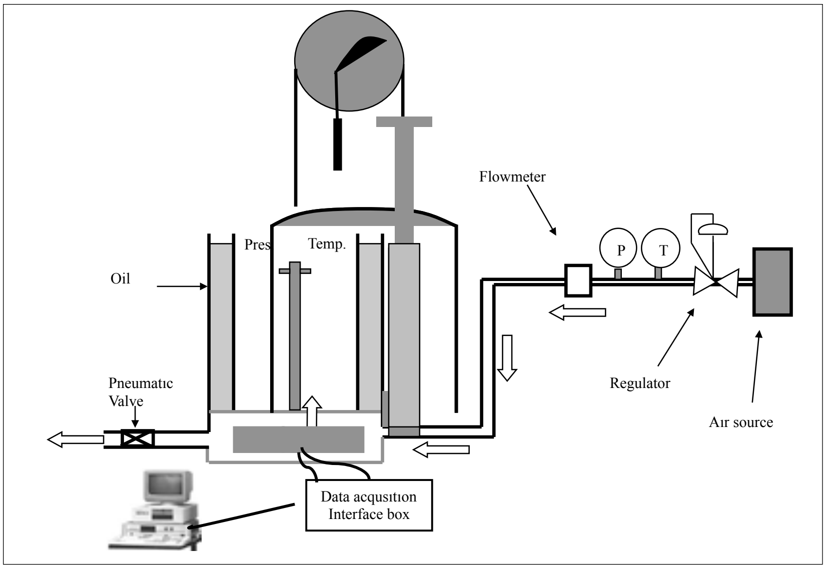

Figure 1. Schematic diagram of bell prover.

shown in Figure 1.

The calculation principle is defined as displaced volume divided by time elapsed during displacement and the flow uncertainty is expressed in these terms by the formula (3).

$$U(Q)=\sqrt{\left(\frac{\partial Q}{\partial D}u(D)\right)^2+\left(\frac{\partial Q}{\partial L}u(L)\right)^2+\left(\frac{\partial Q}{\partial t}u(t)\right)^2} \qquad (3)$$

Diameter D, and displacement length L stands for the inner volume calculation parameters of bell and t for the time measurement. A rotary encoder or a laser interferometer can be used for measurement of displacement length L so it is evident that the formula (3) should be rearranged to involve the pulse information from these transmitters.

The clock triggered by the pulses through hardware is synchronized with the displaced volume so the uncertainties related to time measurements not only depend on the clock oscillator but also on the pulse transmitting system performance both for electronic and mechanical actions. Mechanical consideration is the thermal expansion effect on the radius of a pulley which the rotary encoder has attached to its shaft.

Bell volume determination measurements help us to understand the deviations around a mean value because of deformations due to manufacturing difficulties, poor eccentricity and thermal expansions that may alter the bell diameter. One other parameter affected by the thermal expansion is the counter weight holding curvature. Oil film adherence at the inner surface of the bell is not taken into account during dimensional calibration but introduces additional uncertainties in the flow meter calibration process. Temperature and pressure calibrations are performed at static conditions but real time measurements are done at dynamic conditions which bring an additional uncertainty contribution for the real time representation of the pressure and temperature in the bell, although it is assumed that those parameters are kept constant throughout a stroke of the bell. Percent contributions of the discussed parameters to the overall uncertainty estimated for the TUBITAK UME bell prover system are listed in Table 1.

Uncertainty Parameter	% Contribution to Overall Uncertainty
Temperature	15.0
Pressure	15.0
Bell Volume	44.8
Thermal expansion	2.3
Time measurements	15.5
Vibrations, oil adherence, leakage and vapor pressure	7.4

Table 1. Estimated uncertainty contributions for TUBITAK UME bell prover.

2.1.2 Piston System

Piston systems can be grouped into two categories;

a) A lightweight plastic piston or a layer of soap bubble floats inside a precision bore tube with the pressure of gas flow at constant velocity (Figure 2)

b) The piston moves by the force of a servo motor driven mechanism.

In both cases the flow rate is expressed as the product of the velocity and the cross sectional area of the tube.

The chronometer triggered by the photo detectors placed on the tube helps calculate the piston velocity or sometimes a laser interferometer or an ultrasonic sensor is placed at the top of the tube for a precise measurement of

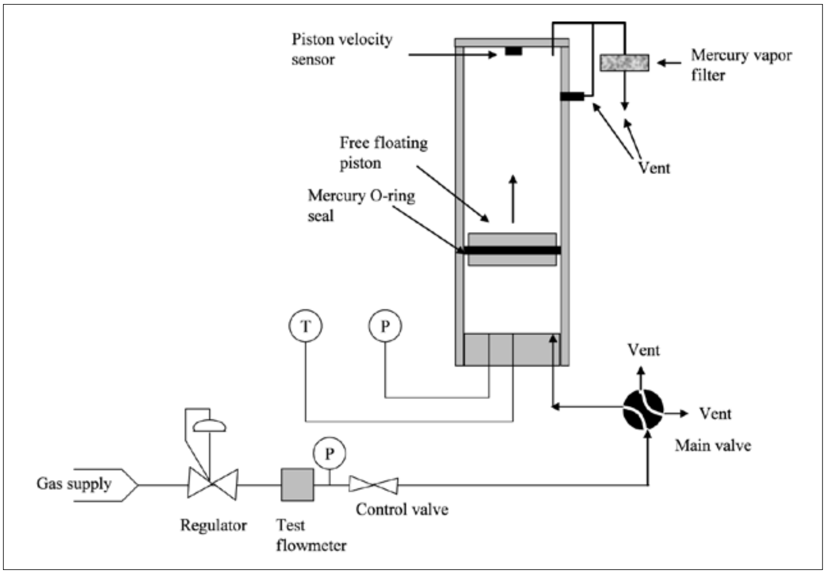

Figure 2. A typical mercury sealed piston system design.

piston displacement. Displaced volume *V* by the piston divided by the elapsed time *t* is the starting point for the uncertainty evaluation as shown in formula (4).

$$U(Q) = \sqrt{\left(\frac{\partial Q}{\partial V}u(V)\right)^2 + \left(\frac{\partial Q}{\partial t}u(t)\right)^2} \quad (4)$$

The main problem and potential source of errors for these designs arises from the fact that collected gas can penetrate or leak from the piston-tube assembly. Substances like mercury are preferred as the o-ring material because it does not stick to the surface and does not leave dirt on the glass tube. Accurate measurement of pressure and temperature is important in the tube because measured flow rate needs to be converted to standard conditions. Whether it is a forced or a free floating piston system, gas density variations or the use of non-ideal gas has the possibility to react with the walls of the tube and large errors in the determination of mass flow may occur.

Uncertainty Parameter	% Contribution to Overall Uncertainty
Volume measurements	35.5
Temperature measurements	24.6
Pressure measurements	25.1
Timing	5.0
Unsteady effect and leaks	9.8

Table 2. Uncertainty contributions for UME free floating piston system.

$$U(\dot{Q}) = \sqrt{\left(\frac{\partial \dot{Q}}{\partial M}u(M)\right)^2 + \left(\frac{\partial \dot{Q}}{\partial t}u(t)\right)^2} \quad (5)$$

$$U(M) = \sqrt{\left(\frac{\partial M}{\partial P_f}u(P_f)\right)^2 + \left(\frac{\partial M}{\partial T_f}u(T_f)\right)^2 + \left(\frac{\partial M}{\partial Z_f}u(Z_f)\right)^2 + \left(\frac{\partial M}{\partial P_i}u(P_i)\right)^2 + \left(\frac{\partial M}{\partial T_i}u(T_i)\right)^2 + \left(\frac{\partial M}{\partial Z_i}u(Z_i)\right)^2 + \left(\frac{\partial M}{\partial V}u(V)\right)^2} \quad (6)$$

Systems using a uniform bubble layer as a piston are subject to humidity effects caused by the liquid solution at the bottom of the tube. Although there is not a generalized statement for this effect, investigations are needed for an accurate measurement of flow measurement for bubble type pistons systems.

One other point of interest about these bubble types is the distortions by the flow on the uniformity of the plane bubble layer. The plane layer takes a convex shape as the flow rate increases so in a sense the shape of the layer determines the flow range of the reference [5]. Percent contributions of the discussed parameters to overall uncertainty calculated for the TUBITAK UME free floating piston system are listed in Table 2.

2.2 Constant-Volume Systems

Constant-volume systems are best represented by PVTt (pressure-volume-temperature-time) designs as illustrated in Figure 3 (page 24). Change of the initial pressure and temperature of a thermally isolated tank after some amount of gas is filled in a short period of time is the basis of the flow rate calculation for these systems. The stored gas in a PVTt tank is allowed to reach steady conditions before the final pressure and temperature measurements so that initial and final data acquired from the transmitters are at static conditions for a measurement sequence. A detailed design and uncertainty analysis of such a system is discussed by J.D.Wright *et al* [3] and it is stated that the more then 60 percent of the overall uncertainty comes from the final temperature and tank volume measurements [4].

Initial and final pressure, temperature measurements and time measurement during gas accumulation in the tank and the inventory volume can be presented by formula (5) and (6) for the uncertainty in mass flow rate and the amount of collected mass respectively. Approximate percent contributions of the parameters to overall uncertainty for NIST PVTt system are listed in Table 3.

Uncertainty Parameter	% Contribution to Overall Uncertainty
Volume measurements	38.7
Temperature measurements	32.4
Pressure measurements	21.1
Reference properties	1.3
Timing	0.1
Unsteady effect and Leaks	5.1
Compressibility	1.3

Table 3. Uncertainty contributions for NIST PVTt system.

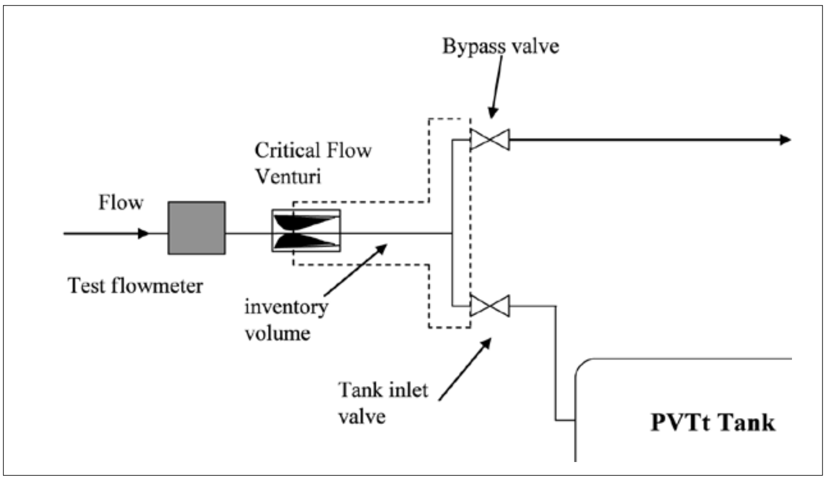

Figure 3. PVTt system design.

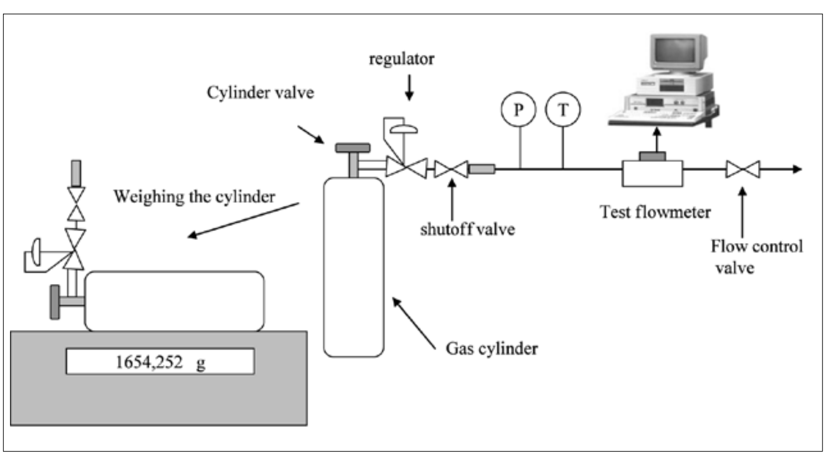

Figure 4. Direct weighing system.

2.3 Direct Weighing Systems

Mass flow rate measurements are performed directly by weighing the gas cylinder before and after the gas have left the cylinder. Contributing errors are limited to mass and time measurements and no assumptions about gas compressibility have to be made. No density correction required for this method so it is considered potentially more accurate than volumetric systems. Large quantities of gases needed to be weighed in order to have an accurate weight measurement but because of low density problems ratio of the gas weight to the tare weight of the cylinder is very small. This means that the balance that is used for this purpose should detect microgram or even nanogram amounts. For example if the accuracy (or resolution) of the balance is 50 mg, you will have to discharge 50 g of gas to obtain a 0.1 % weighing uncertainty [6].

The importance of the dimensional accuracy and uncertainty for volumetric reference standards is not valid for this method so that corrosive and reactive gas flow meters can be calibrated for low flow rates by these systems.

Mass weighing and elapsed time measurement are the basis of the mass flow rate uncertainty evaluations as expressed by the formula (5) in constant-volume system section.

3. Results

Four different systems were reviewed in this paper and the related uncertainties were discussed for the gas flow rate reference measurement systems. It has been concluded that each flow calibrator has unique advantages, disadvantages, sources of error, and associated instrumentation requirements to reach lower uncertainties.

One should consider all the sources of uncertainty like system design, sensor response times, warm-up times, neglected compensations, etc before making a final decision about the best reference system for a

Uncertainty Parameter	% Contribution to Overall Uncertainty
Balance	65,2
Buoyancy correction	3,7
Repeatability	14,1
Refernce properties	1,1
Time measurements	12,9

Table 4. Uncertainty contributions for direct weighing system.

specific measurement. It is seen that although temperature and pressure sensors used for these purposes are very accurate in the sense of measured quantities and response times, they do not perform the same accuracy when placed on the real systems. Sensitivity to temperature or pressure change requires some time to ensure stabilization has been reached but for some systems this period may not be allowed because of measurement system design limitations.

Researchers will continue to discuss the conventional flow measurement systems that provide long-term stability for reliable measurements within the accepted degree of uncertainty until the new systems are established by the application of first principles of physics.

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Ilker Meral received a B.Sc. in Physics from the Middle East Technical University and he has been working at the National Metrology Institute of Turkey (UME) as a researcher in the field of dimensional metrology since 1997.

Manual / Automated Decade Resistance Using Microcontroller Technique

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National Institute of Standards (NIS), Egypt

An ordinary decade resistance is made of ten resistive elements for obtaining ten resistance values with a constant step. A resistance box is composed of more than one decade. In this paper, a new design for a decade resistance formed by four resistive elements is introduced. This decade is manufactured to be controlled by using a micro-controller technique as demonstrated in this research. Its ten resistance steps can be obtained by manual control through a designed assembly language program with push-button switches or by automatic control through a designed LabView® program and a computer serial port. All of the control signals are transmitted to the four resistors by the corresponding four electronic relays. The ten-output values of the resistance steps of this new decade resistance are accurately calibrated through this investigation. Analysis of the measurement results is carefully performed including the uncertainty calculations to validate this new fabricated decade resistance.

Editor's note: Dr. Raouf's paper "Fabrication of a New Decade Resistance Using Parallel Port Technique" was presented in the Oct-Dec 2009 issue of Cal Lab. This paper reports on further development that has produced a decade resistance device with automatic and manual controls using advanced techniques.

1. Introduction

Decade resistances are used in many measurement bridges such as an admittance ratio bridge (parallel resistance capacitance bridge) [1], series resistance capacitance bridge [2], Schering bridge [3], and others [4]. They are also used to calibrate dissipation factor standards [5]. Decade resistances are usually constructed by ten resistive elements to get ten resistance steps values. Usually more than one decade are connected together to form a resistance box as illustrated in Figure 1a. It has the internal construction shown in Figure 1b.

A five-elements decade resistance is fabricated in [6], while its calibration is carried out according to an accurate calibration technique [7]. All of these decades are operated manually. In digital-to-analog converters, by adjusting voltage to current values any required reistance value can be obtained using electronic networks [8]. Unfortunately, electronic circuits have eventual limits and restrictions on both measurement accuracy and precision, and they have other limitations such as the linearity of the amplifiers and the temperature effects [9].

In this paper, microcontroller technique is introduced to accomplish manual and automatic control of the output resistance steps of the four elements decade resistance. Manual control is achieved using a prepared assembly

Figure 1a. Resistance box with five decades.

Figure 1b. Ten resistive elements per decade.

Figure 1. Common manual resistance box with ten elements per decade.

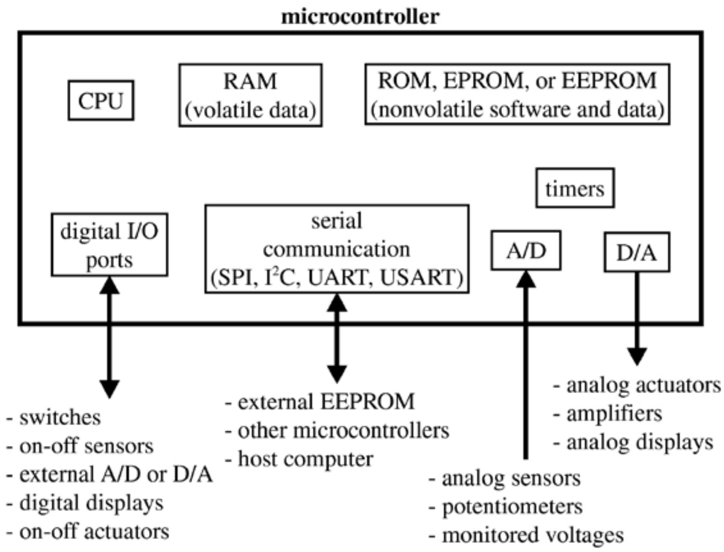


Figure 2. Components of a typical full-featured microcontroller.

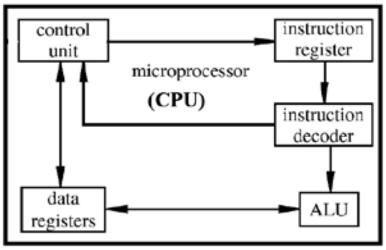


Figure 3. Microprocessor architecture.

language program with push-button switches and four electronic relays. Automatic control is achieved using a prepared LabView® program through a computer serial port and the same four electronic relays. Accurate measurements of the decade resistance steps are carried out to verify and to validate this new design and fabrication. Measurement results are studied and their uncertainty calculations are reported.

2. Microcontroller Technique

A microcontroller is an entire computer manufactured on a single chip. Figure 2 demonstrates a block diagram of a typical full-featured microcontroller. Typical external devices that might interface to the microcontroller are included in this figure.

The components of a microcontroller include the microprocessor, which is called the central processing unit (CPU), RAM, ROM, digital I/O ports, a serial communication interface, timers, A/D converters, and D/A converters. A microprocessor is a single, very large scale integration (VLSI) chip that contains many digital circuits, which perform arithmetic, logic, communication, and control functions. The architecture of a microprocessor is illustrated in Figure 3.

The arithmetic logic unit (ALU) within the CPU executes mathematical functions on data entered as binary words. A word is an ordered set of bits, usually 8, 16, 32 or 64 bits long. The instruction decoder interprets instructions fetched sequentially from memory by the control unit, which stores the instructions in the instruction register.

Each instruction is a set of coded bits that commands the ALU to perform bit manipulation, such as binary addition and logic functions, on the words stored in CPU data registers [10]. The ALU results are also stored in data registers and then transferred to memory by the control unit. It is stored in a read only memory (ROM) and executed by the CPU. Hence, It executes the software and controls all the microcontroller components, shown in Figure 2.

The microcontroller random access memory (RAM) is used to store setting and values used by an executing program. It can be read from or written to at any time, when provided power is maintained. The data in RAM is considered volatile, because it is lost when power is removed.

ROM is used for permanent storage of data that the CPU can read, but the CPU cannot write data to ROM. It does not require a power supply to retain its data and therefore is called nonvolatile memory. A designer can have a program and data permanently stored in ROM by the chip manufacturer, or the ROM can be in the form of erasable-programmable ROM (EPROM) or electrically EPROM (EEPROM), which can be reprogrammed by the user.

Software permanently stored in ROM is referred to as firmware. Microcontroller manufacture, offer-programming devices that can download a compiled machine code file from a personal computer (PC) directly to the EEPROM of the microcontroller. This can be done through some microcontroller pins that can be used usually for other purposes after the device is programmed. Additional EEPROM may also be available and used by the program to store settings and parameters generated or modified during execution.

The microcontroller has many pins as shown in Figure 4, hence, the digital I/O ports indicated in Figure 2 allow binary data to be transferred to and from the microcontroller using these external pins on the IC. These pins can be used to read the state of switches, on-off sensors, and to

Figure 4. External pins of a microcontroller.

Switch number	States of the four electronic relays				Equivalent resistance
	Relay 1	Relay 2	Relay 3	Relay 4	
S0	1	1	1	1	0
S1	0	1	1	1	1R
S2	1	0	1	1	2R
S3	1	1	0	1	3R
S4	1	1	1	0	4R
S5	1	0	0	1	5R
S6	1	0	1	0	6R
S7	1	1	0	0	7R
S8	0	1	0	0	8R
S9	1	0	0	0	9R
S10	0	0	0	0	10R

Table 1. Combinations of the four resistive elements to obtain the ten output steps (1-closed, and 0-open).

interface to external analog-to-digital actuators. The I/O ports can be used also to transmit signals to and from other microcontrollers to coordinate various functions. The microcontroller can also use a serial port to transmit data to and from external devices, provided these devices support the same serial communication protocol. Examples of such devices, computers and external EEPROM memory ICs that might store a large block of data for the microcontroller as illustrated in Figure 2.

In addition, the microcontroller may be connected to other microcontrollers that need to share data, or to a host computer that might download a program into the microcontroller onboard EEPROM. There are various standards or protocols for serial communication including serial peripheral interface (SPI), interintegrated circuit (I^2C), universal asynchronous receiver-transmitter (UART), and universal synchronous-asynchronous receiver- transmitter (USART).

The analog to digital (A/D) converters allows the microcontroller to convert an external analog voltage to a digital value that can be processed or stored by the CPU. The digital to analog (D/A) converters allows the microcontroller to output an analog voltage to a non-digital device. Hence, A/D, D/A converters and digital I/O ports, provide interfaces to switches, sensors and actuators. Onboard timers are usually provided to help create delays or ensure events occur at precise time intervals. (e.g., reading the value of a sensor). To drive all of the microcontroller components shown in Figure 2, a software program is stored in its ROM. Software programs can be written in a high–level language such as BASIC or C, or by the machine language (assembly) [11].

3. Design of a New Decade Resistance Using Microcontroller Technique

The new four-elements decade resistance fabrication is mainly based on an AT89C52 microcontroller and four electronic relays. This decade resistance has four-resistive elements having nominal values of $R_1 = R$, $R_2 = 2R$, $R_3 = 3R$, and $R_4 = 4R$, where R is the nominal value of the resistance per decade step. The ten output resistance steps can be obtained by using ten push-button switches connected to the microcontroller to generate the stored binary code, listed in Table 1, for any required resistance step. To obtain automatic control, the microcontroller is also connected to the computer serial port described in Table 2.

As commonly known, serial communication requires three lines (wires) to transmit and receive data. Then, the four bit words of a binary code listed in Table 1 are transmitted to the four electronic relays using three lines named TD, RD, and SG which have pins 2, 3, and 5, respectively, as illustrated in Table 2. Therefore, the four resistive elements of this new decade are connected to the microcontroller through the four electronic relays to have manual control through the push-button switches or automatic control through the computer parallel port as demonstrated in Figure 5.

Manual and automatic controls of the output of the new decade resistance are accomplished by assembly and LabView programs respectively that contain the four bits binary code indicated in Table 1, as will be explained in the next section.

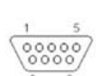
Shape	D-Type-9 pin no.	Pin outs	Function
	3	RD	Receive Data (Serial data input)
	2	TD	Transmit Data (Serial data output)
	7	RTS	Request to send (acknowledge to modem that UART is ready to exchange data
	8	CTS	Clear to send (i.e.; modem is ready to exchange data)
	6	DSR	Data ready state (UART establishes a link)
	5	SG	Signal ground
	1	DCD	Data Carrier detect (This line is active when modem detects a carrier
	4	DTR	Data Terminal Ready.
	9	RI	Ring Indicator (Becomes active when modem detects ringing signal from PSTN

Table 2. Serial port configurations of a D-Type.

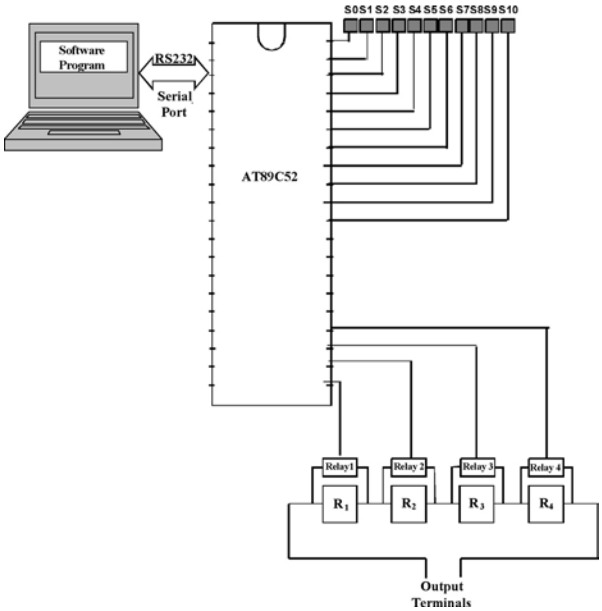


Figure 5. Design of the manual/automated decade resistance.

Figure 6. Manufactured circuit of the new fabricated decade resistance.

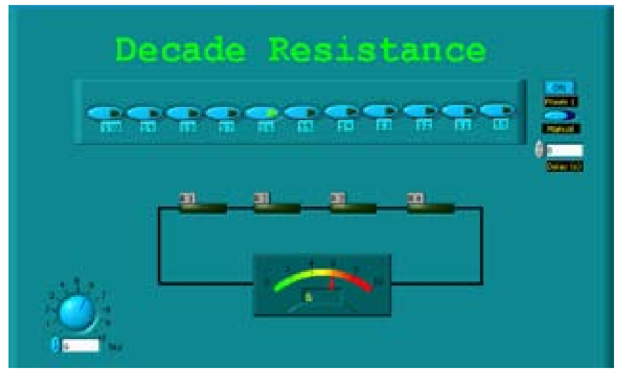


Figure 7. LabView program designed to control the new fabricated decade resistance.

4. Fabrication of the New Decade Resistance

The fabricated decade resistance consists of four resistive elements having nominal values of $R_1 = 1$ kΩ, $R_2 = 2$ kΩ, $R_3 = 3$ kΩ, and $R_4 = 4$ kΩ ,and four electronic relays that receive the control signal from AT89C52 for the required resistance step to be existed at the decade output terminals as shown in Figure 6.

Manual control without the computer is achieved when one of the ten push-button switches, shown in Figure 6, is pressed; the AT89C52 microcontroller examines the address of this switch and generates the corresponding four bit binary word that is received by the four electronic relays. Then the required resistance step is measured across the decade output terminals. This binary code, listed in Table 1, is stored in the microcontroller ROM through an assembly language program. It includes also all other software instructions to be executed by the CPU.

To obtain any required step, for example 6 kΩ by pressing the corresponding push-button switch, the stored assembly program generates the corresponding binary word by the microcontroller. This four bit word is (1010) which makes only relays number 2 and 4 disconnect and relays number 1 and 3 connect and short their resistances. Hence, the equivalent resistance value of R2 and R4 is measured at the decade output terminals. And so on, for any required step from the ten output steps of this four elements decade resistance. (i.e. from 1 kΩ to 10 kΩ with step 1 kΩ).

Automatic control is achieved by connecting this decade to the computer through the serial port cable shown in Figure 6. The same binary code is stored in the computer through a LabView program shown in Figure 7.

The code of the required step is transferred to the microcontroller through its serial port shown in Figure 2. The microcontroller transmits this four bit signal to the four electronic relays to obtain the corresponding resistance step value as previously described. Using the LabView program we can choose the manual operation to obtain the 6 kΩ resistance value, for example, as illustrated in Figure 7. If automatic control is required, then all of the decade resistance steps are obtained with any required sequence and delay time by using the automatic option in this custom made program as shown in Figure 8.

Hence, the ten-output steps of this decade resistance are accurately measured and the necessary computations and analysis are curried out, therefore the decade performance can be evaluated.

5. Measurements and Analysis of the Decade Resistance Step Values

Accurate measurements of this new fabricated decade resistance are precisely obtained by using a Fluke model 8508A digital reference multimeter. The internal circuits and their operation theories of this device are clearly introduced in [12], illustrating in detail all functions that can be

Figure 8. Automatic operation of the LabView program.

Figure 9a.
Manual resistance steps.

Figure 9b.
Automatic resistance steps.

Figure 9. Measurements of the new fabricated decade resistance steps.

measured and their possible ranges. Figure 9 illustrates the new fabricated decade resistance connected to the described precision multimeter which is used to measure the output values of the ten resistance steps obtained by either manual control (Figure 9a), or by automatic control (Figure 9b).

Each decade step value is measured at least ten times and the average resistance value of each one is recorded in Table 3 and combined with the relative percentage error that is computed according to the following equation:

$$\Delta_{step} = \frac{Actual\ Value - Nominal\ Value}{Actual\ Value} * 100\ \% \quad (1)$$

Each step actual value is represented against its step number in the diagram demonstrated in Figure 10. Figure 11 also illustrates step percentage error values of the new fabricated decade resistance.

The available commercial four resistive elements used in manufacturing this new fabricated decade resistance are the main source of error. The represented step errors declare how far the actual step values of resistance vary from its nominal values. In the following analysis, all of the decade resistance step errors are referred to the average error of all steps (Δ_{ave}), which can be expressed as:

$$\Delta_{ave} = \frac{1}{10} \sum_{step=1}^{step=10} \Delta_{step} . \quad (2)$$

Referring to Table 3, Δ_{ave} of all decade steps is computed by using Equation 2, to be equal to 0.613323 % , then all decade step errors are referred to Δ_{ave} as shown in Table 4.

By examining Table 4, and Figure 12, the behavior of the new fabricated decade resistance can be investigated. Hence, internal resistors of the decade, which give high step errors relative to the average decade error, should be replaced to enhance the decade performance. Noticeably, step 1 and step 2 have higher errors with respect to the other steps. Moreover, the resistance actual values of the ten-decade steps should be combined with their expanded uncertainties.

Step Number	Nominal Value (kΩ)	Actual Value (kΩ)	Δ_{Step} (%)
1	1.0000000	1.0048630	0.4839495
2	2.000000	2.016140	0.800530
3	3.000000	3.019320	0.639863
4	4.000000	4.020513	0.510218
5	5.000000	5.031440	0.624867
6	6.000000	6.036863	0.610623
7	7.000000	7.043051	0.611261
8	8.000000	8.047211	0.586678
9	9.000000	9.058304	0.643655
10	10.000000	10.062548	0.621589

Table 3. Average values of the decade resistance steps with their relative percentage errors.

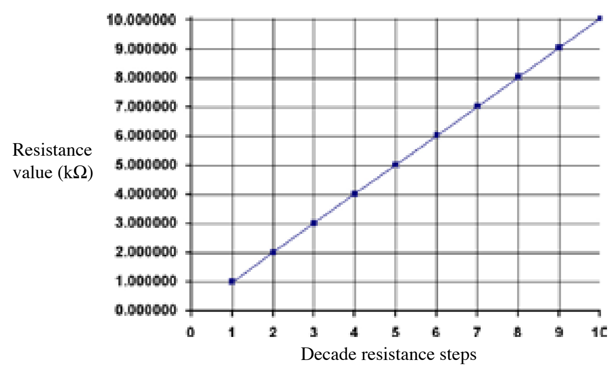


Figure 10. Representation of the actual values of the decade resistance steps.

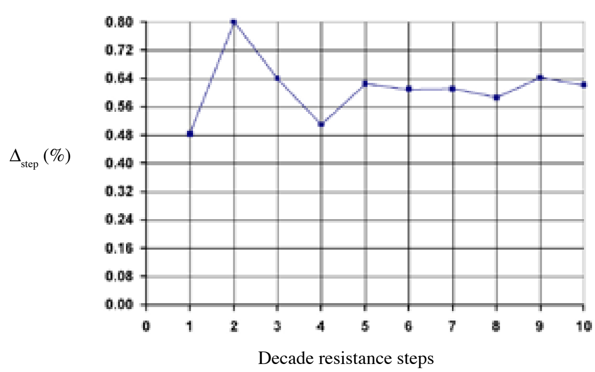


Figure 11. Percentage error of each decade resistance step.

Step NO.	1	2	3	4	5	6	7	8	9	10
(Δ_{Stp} - Δ_{ave}) %	- 0.1294	0.1872	0.0265	- 0.1031	0.0115	- 0.0027	- 0.0020	- 0.0266	0.0303	0.0083

Table 4. Value of (Δ_{Step} - Δ_{ave}) % for each decade resistance step.

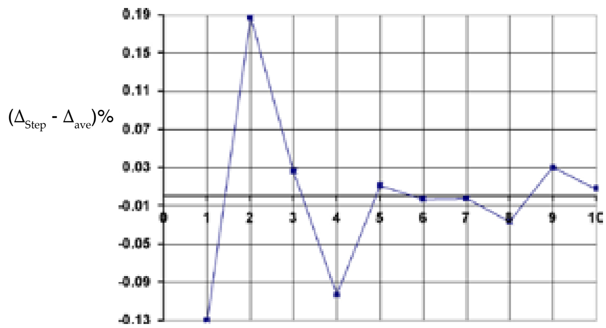


Figure 12. Performance of each decade resistance step.

6. Uncertainty Estimation

Uncertainty estimation for the performed measurements of the new decade resistance steps are carried out. The uncertainty budget for each decade step consists of three items: measurements repeatability, multimeter calibration certificate, and multimeter resolution. Repeatability is considered as Type A contribution, while multimeter calibration certificate, and multimeter resolution are considered as Type B contribution. Then, uncertainty values of the all resistance steps are computed according to [13] and [14]. Therefore, the final resistance value of each decade step can be expressed as listed in Table 5 at 95.54 % confidence level with coverage a factor two, i.e. (K=2.0).

7. Conclusions

The new four-elements decade resistance is mainly manufactured and fabricated based on a AT89C52 microcontroller and four electronic relays. It has separate manual and automatic controls; by using push-button switches through the assembly program and by using LabView through a computer and serial port, respectively. Accuracy of this decade resistance mainly depends on the accuracy of the used four resistive elements. This new fabrication technique can be applied to the manufacture of any decade resistance with any required step values to any desired level of accuracy while providing manual and automatic operation modes.

Step Number	Nominal Value (kΩ)	Actual resistance step value with its expanded uncertainty
1	1.0000000	1.0048630 kΩ ± 63 ppm Or 1.0048630 kΩ ± 6.3 E-05 kΩ
2	2.000000	2.016140 kΩ ± 38 ppm Or 2.016140 kΩ ± 7.7 E-05 kΩ
3	3.000000	3.019320 kΩ ± 18 ppm Or 3.019320 kΩ ± 5.5 E-05 kΩ
4	4.000000	4.020513 kΩ ± 7 ppm Or 4.020513 kΩ ± 2.9 E-05 kΩ
5	5.000000	5.031440 kΩ ± 27 ppm Or 5.031440 kΩ ± 13.3 E-03 kΩ
6	6.000000	6.036863 kΩ ± 27 ppm Or 6.036863 kΩ ± 16.5 E-05 kΩ
7	7.000000	7.043051 kΩ ± 7 ppm Or 7.043051 kΩ ± 5.2 E-05 kΩ
8	8.000000	8.047211 kΩ ± 8 ppm Or 8.047211 kΩ ± 6.4 E-05 kΩ
9	9.000000	9.058304 kΩ ± 9 ppm Or 9.058304 kΩ ± 7.9 E-05 kΩ
10	10.000000	10.062548 kΩ ± 5 ppm Or 10.062548 kΩ ± 5.2 E-05 kΩ

Table 5. Final results of the measurements of the new fabricated decade resistance steps for K=2.0.

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Metrology for a Competitive Advantage

Rick Rios, John Brandon
JTI Systems, Inc.

Metrology impacts the entire product life cycle (PLC). From R&D to product shipment, metrology systems and their data are used to: establish product specifications, determine if the results of a specific measurement conform to stated specifications and customer requirements, monitor environmental, safety and health parameters, report results in external publications, inspect products and services, establish data used for marketing purposes, verify and validate processes and products. Yet, in most organizations there is no coherent and integrated metrology program, just individuals working in silos, doing their best! At best there may be a calibration program, but calibration is just one small piece of metrology. There is no organizational system or process that looks at or understands the metrology requirements — capability, traceability and stability — from R&D to product shipment. As a consequence, organizations miss product market windows, have high warranty issues, put reputations at risk, confront regulatory issues, and the impact to the bottom line is significant. The author's objective is that upon reading this paper, management, production, calibration and technical laboratory personnel will have a better understanding of the major pieces and requirements of a metrology system. And, they will recognize that fully understood and applied, metrology could be a source of competitive advantage for their organization.

Product Quality and Compliance Starts With Metrology

In the hyper-competitive world of global business, companies continually look for opportunities to achieve a competitive advantage. Quality methodologies such as Six Sigma, Shingo, Lean Manufacturing and Baldrige all represent attempts at gaining an edge over the competition. But what each of these methodologies misses is the fundamental fact that quality starts with metrology. The reason most organizations miss this fact is because they equate metrology with calibration. This view: metrology equals calibration is like comparing:

Biology – "the science that studies living organisms" versus *a medical examination*

or

Chemistry – "the science of matter; the branch of the natural sciences dealing with the composition of substances and their properties and reactions" versus *a chemical analysis*

or

Metrology – "the science of measurements" versus *a calibration report*

Across the product life cycle, from research, design and development, pilot (clinical trials), to volume production, every function uses measurement data to determine if indeed the product meets specifications. A calibration report can tell us whether a particular piece of test and measurement equipment is functioning within acceptable parameters. Metrology can tell us what equipment should be used, what the operating environment conditions should be, how the equipment should be used, the training that should be required of all operators, the degree of measurement uncertainty and much more. Calibration is just one small piece of metrology.

For most organizations, however, metrology is far from being a potential source of competitive advantage. In fact, this basic lack of understanding of metrology has created an unrecognized, growing risk between what is technically required for metrology systems and what is being designed/delivered for product life cycle phases across industries and organizations. And, many organizations operate under a false sense of security due to inadequate FDA, ISO and internal audits based on quality systems not metrology.

Metrology's Footprint on the Product Life Cycle is Huge

The myopic view of metrology has cast a shadow over the fact that measurement data is being used to set performance and product specifications, monitor environment, safety and health parameters, verify and validate processes and products, and achieve regulatory compliance across the entire product life cycle. ***The question each reader needs to ask: Is metrology involved across the entire PLC in my organization?***

The Opportunity: Metrology for a Competitive Advantage

What does it mean to have a "competitive advantage?" A three part definition first heard from Steve Wheelwright at the Stanford Business School has served us well. In order

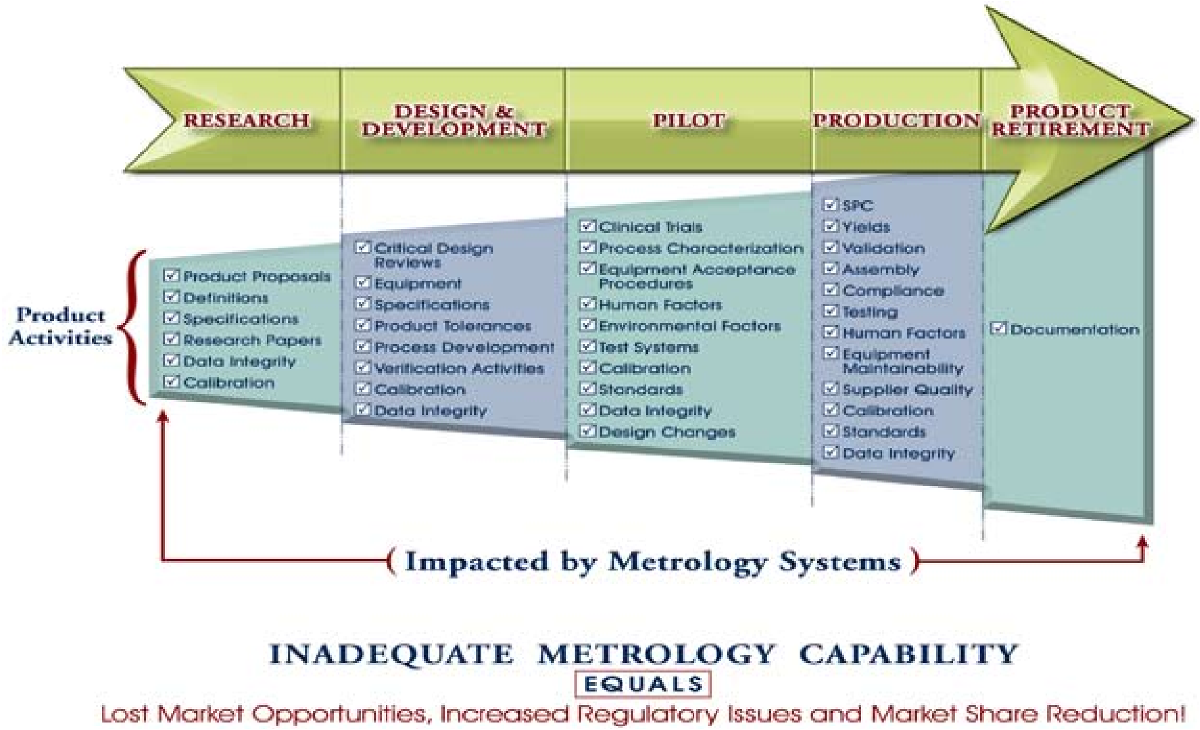

Figure 1. The Metrology footprint spans across the entire Product Life Cycle.

to have a *true* competitive advantage you need to be able to do things better than your competitors. That is, you need to possess the right set of capabilities so that you can get new products to market faster or produce higher volumes with fewer rejects or have fewer costly supplier quality misadventures. Your advantage needs to be sustainable over time. Beating the competition to market once does not constitute a competitive advantage. Repeatedly being faster to market than your competition does. Sustainable over time implies that the source of your advantage is hard to duplicate. And, finally, what you are doing has to be valued by your customers!

Years ago, while working for a computer manufacturer with unquestionably the strongest technical capabilities in the industry, we had the unfortunate ability to produce exquisite machines that the customers didn't want to buy.

At the corporate level, senior executives focus on issues like time to market for new products, market share, manufacturing costs, issues that directly impact the overall strength and profitability of the organization. They are continually asking their managers to find ways in which they can improve their performance, where they can develop an advantage over the competition.

So then, how does metrology impact, for example, time to market? First by definition, the output of any metrology system (the measurement process) is data. Data is used to verify and validate the quality of the product as it is being designed and produced. Simply stated, lack of (or a lack of confidence in) timely, appropriate, and accurate measurement data increases the development, engineering, production and validation time of the product development cycle. Whether managers realize it or not, and some don't, the need for measurement data that you have profound confidence in is paramount to achieving reduced time to market (or reducing manufacturing costs). Recognized or not, the reality is that metrology is in the middle of all the action. The question then becomes: "Is metrology ready for the game?"

The Right Stuff: Metrology Capabilities for a Competitive Advantage

To gain a metrology competitive advantage requires that an organization's metrology function be able to determine, control and improve the (1) capability, (2) traceability and (3) stability of the measurement process throughout the product life cycle.

Measurement System Capability: is the ability of the measurement process to measure the unit (characteristic) under test within the required product performance parameters. To understand the capability of a measurement process requires that the measurement variation of the process be determined and controlled; the quantification of measurement variation is called measurement uncertainty.

Measurement System Capability includes the following:

- Have the right product specifications/tolerances (Product specifications determine the design and required capability of a measurement system)
- Design the right measurement system
  - ✓ Instruments
  - ✓ Procedures
  - ✓ Operators
  - ✓ Check Standards
  - ✓ Environment
- Conduct a measurement system validation
- Determine the measurement uncertainty
- Implement a process measurement assurance program

Measurement System Traceability: is the ability to demonstrate the accuracy of a measurement result in terms of a known standard. The definition of traceability is:

> *"The property of a result of a measurement whereby it can be related to appropriate standards, generally international or national standards, through an unbroken chain of comparisons all having stated uncertainties."*
> *(NIST.gov – Policy on Traceability)*

Measurement system traceability includes the following:

- Design the Right Calibration System
  - ✓ Instruments
  - ✓ Procedures
  - ✓ Operator Training
  - ✓ Standards
  - ✓ Environment
  - ✓ Calibration
- Conduct a standards traceability tree uncertainty analysis
- Conduct supplier qualification audits
- Control documents and records
- Implement a process measurement assurance program

Measurement System Stability (reliability): is the ability of the measurement system to repeat the measurement over time given all the dynamics and interactions of the measurement process. To ensure measurement system stability the measurement variation must be determined and controlled, i.e, measurement uncertainty.

Measurement System Stability includes the following:

- Implement a process measurement assurance program
- Determine calibration intervals based on historical data

The common link between measurement capability, traceability and stability is the determination and control of the measurement variation (uncertainty) of the measurement process.

The metrology (management) tool to accomplish this is called a process measurement assurance program (PMAP)[1]. PMAP determines and controls the capability, traceability and stability of a measurement system.

Conclusion

As stated in the abstract, in most organizations there is no coherent and integrated metrology program. There may be a calibration program, but calibration is just one portion of metrology. There is no organizational system or process that looks at or understands capability, traceability, and stability, the keys to an organizational advantage. What difference does it make? In many high-tech industries the economic difference to the company between being first to the market and runner-up is staggering. In more stable industries efficient output in the production environment is crucial to cost containment and the ability to aggressively price the product. Fully engaged with the right capabilities, metrology could be a source of competitive advantage.

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DH Instruments Announces Increased Range to 2,000 psi Pressure Controller/Calibrator

The DH Instruments Division of Fluke Corporation has announced a significant enhancement to its PPC4 product line. The PPC4 is a high performance pressure calibrator for testing pneumatic pressure instruments. The maximum pressure range of the PPC4 has increased to cover the absolute pressure range of 1 kPa (0.15 psi) to 14 MPa (2,000 psi) and gauge pressure equivalent, including very low differential pressures.

The patented dynamic control is further improved, extending the minimum controlled pressure down to 1 kPa. PPC4 enables users to select the user interface that best fits their application and budget. Bench top users can select the advanced graphic color display with point-and-click navigation to streamline pressure calibration and testing tasks. The advanced graphical user interface now supports 11 different languages; Chinese (simplified), Chinese (traditional), Czech, English, French, German, Italian, Japanese, Portuguese, Russian and Spanish.

If PPC4 spends most of its time interfaced with a computer, choose the basic front panel to minimize cost. Both interfaces include a front panel USB connection and free cockpit software for full PC-based 'plug and play' functionality. DHI's COMPASS for Pressure calibration assistance software provides an advanced off-the-shelf tool to quickly automate your calibration and testing processes and handle a wide array of special requirements. PPC4 uses DHI's exclusive, individually characterized, quartz reference pressure transducer (Q-RPT) modules for increased precision and reduced measurement uncertainty. The AutoRange™ feature supports infinite ranging, automatically optimizing all aspects of operation for the exact range of the device being calibrated. It is rugged enough for mobile applications and standard shipment without special packaging.

DHI, visit www.dhinstruments.com, tel 602-431-9100, dhi@fluke.com.

Stranaska Announces CA2M Photometric Calibration Artifacts

Stranaska announces new calibration artifacts for spectrophotometers providing validation of photometric absorbance or transmittance in the visible spectral region. The three filters have nominal transmittance densities of 1.0, 2.0 and 3.0 absorbance units (corresponding to 10%T, 1%T and 0.1%T, respectively).

Each filter is certified for transmittance and transmittance density (absorbance) at the five traditional NIST wavelengths for neutral-density glass filters: 440.0 nm, 465.0 nm, 546.1 nm, 590.0 nm and 635.0 nm. The certified results for each filter is traceable to the NIST national high-accuracy reference spectrophotometer (the primary standard) via a metrological pathway of appropriate NIST transfer artifacts (SRM 930e, SRM 1930 and SRM 2930).

Because modern commercial UV/VIS absorption spectrophotometers have photometric ranges to at least 3 absorbance units, CA2M 761 is particularly well suited as a qualification reference material standard for use by calibration and metrology organizations in validating spectrophotometer specifications (photometric accuracy and linearity) over three orders of magnitude (0-3 absorbance units).

CA2M 772 is comprised of two neutral-density metal-on-quartz (fused silica) filters. Based on the unique "sandwich" design of NIST SRM 2031, the two filters comprising CA2M 772 have nominal transmittance densities of 1.5 and 2.0 absorbance units (corresponding to 3%T and 1%T, respectively).

Each filter is certified for transmittance and transmittance density (absorbance) at four of the traditional NIST wavelengths for SRM 2031a: 250.0 nm, 280.0 nm, 340.0 nm and 360.0 nm. The certified results for each filter is traceable to NIST. CA2M 772 extends the scope of UV certification of NIST SRM 2031a upwards to 2 absorbance units. Comprised of neutral-density metal-on-quartz (fused silica) filters, CA2M 772 conveniently avoids the need to use chemical solutions sealed in fragile cuvettes.

Advanced measurement assurance practices and metrological standardization (reference material artifacts, traceability, uncertainty analysis, and report transparency) underpin the company's array of CA2M standards. The Stranaska measurement services program is distinguished by the international recognition and scientific expertise of its key staff in UV/VIS spectrophotometric metrology, including prior leadership responsibility for the production and certification of spectrophotometric standard reference material (SRM) transfer artifacts in NIST's Chemical Science and Technology Laboratory.

Stranaska, tel 970-282-3840, fax 970-282-7040, labmeasure@stranaska.com, www.stranaska.com.

Agilent Technologies Announces 9000 Series DSO with 600 MHz to 4 GHz Bandwidth

Agilent Technologies Inc. has expanded its mixed-signal and digital-storage oscilloscope portfolio with two lower-cost 600-MHz Infiniium 9000 Series models, three new application packages and GPIB compatibility. The 9000 Series is the industry's first oscilloscope family to offer bandwidths from 600 MHz to 4 GHz, and it includes the industry's first mixed signal oscilloscope to support MIPI and SATA industry standards.

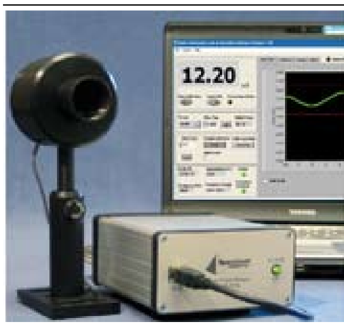
In addition to extending its lineup with lower-cost models, Agilent has added new applications that capitalize on higher-bandwidth 9000 Series models. Emerging serial bus standards in the wireless mobile industry have created the need for teams to debug and test devices that meet MIPI-DPHY physical-layer standards. Agilent's 9000 Series is the first mixed-signal oscilloscope to offer MIPI-DPHY compliance test and protocol analysis enabling faster development of wireless mobile products employing MIPI standards. Teams can quickly move from physical-layer to protocol-layer measurements and can use the compliance application to automate testing to ensure compliance with MIPI-DPHY standards.

Development teams working on electronic products that include storage may have cost constraints or legacy requirements that make SATA 1 a better choice than other interface technologies.

Engineers using Agilent's 9000 Series scopes can quickly see SATA 1 information at the physical and protocol layers. For development teams using the faster 3-Gbs SATA II standard, Agilent offers both compliance and protocol support with its Infiniium 90000 Series.

While LAN and USB IO have reduced the need for traditional programming over GPIB interfaces, many engineers continue to rely on programmatic interaction with oscilloscopes via GPIB. Agilent's new GPIB-to-LAN adapter enables GPIB applications on a computer to interface transparently to an instrument with a LAN interface as if it were a GPIB instrument. This adapter broadens the number of test environments that are ideal for the Infiniium 9000 Series scopes.

Agilent Technologies, Inc. www.agilent.com/find/9000.



Spectrum Detector Introduces Broadband Radiometer for Power Measurements through THz

Spectrum Detector, Inc., a leading manufacturer of Pyroelectric Detectors and Instruments, introduces the T.rad Series of Broadband Digital Radiometers with incredible sensitivity in the FAR IR and THz spectrum (0.1 to 100 THz). The ability to measure 50 nW with 2nW resolution was recently made possible by the development of a state of the art, thin film crystalline Pyroelectric detector and unique Lock In Amplifier Software.

The new T.rad Radiometer Probes are available with three detector areas …1.5, 5 and 9 mm diameter. The Pyroelectric detector and pre-amplifier are mounted in a metal housing that includes a thermal isolation enclosure that has an SM1 threaded front bezel that takes windows, optics and filters. A radiometer system is composed of a probe and our LIA-DPM Digital LockIn Module. Install our executable LabView® Software, plug the T.rad probe into the LIA-DPM electronic module and connect it to your PC with a USB cable and you're ready to measure your broadband IR or THz source.

Our Lock In Amp software is very versatile yet simple to use and includes multiple user screens …Strip Chart, Statistics, Tuning and Setup. The instrument controls are always visible on the left hand side of the display. While displaying measurement data on the computer, you can also choose to log data, creating a file with a specified batch size, which will be stored in host computers memory. You can recall these data files and analyze them at anytime.

Spectrum Detector, Inc., dond@spectrumdetector.com, tel 503-697-1870, www.spectrumdetector.com.

Mettler Toledo Introduces Ultra-Micro and Microbalances

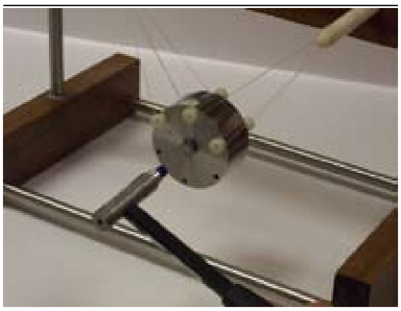
Mettler Toledo is pleased to introduce a line of ultra-micro and microbalances to the current Excellence Plus and Excellence line of analytical balances. The XP6U and XP2U ultra-microbalances and the XP6 microbalance with up to 6 g capacity and 0.1 μg or 1 μg readability, provide incomparable measurement accuracy, user friendliness and quality standards. The Excellence XS3DU microbalance offers fundamental functionality with superb weighing performance in a 800 mg fine range, with a 1 μg readability. Whenever the highest precision is needed: XP6U and XP2U ultra-microbalances and XP6 and XS3DU microbalances are the safe choice for valuable samples.

The Mettler Toledo XP6U is the top level ultra-microbalance with an unmatched 61 million digit resolution. The Mettler Toledo XP2U is an innovative ultra-microbalance, providing optimal weighing performance, user friendliness and quality standards. The XP2U ultra-microbalance has a very high resolution: 21 million digits. Combined with all other XP related characteristics, like colored touch-screen display, customized screen programming, intelligent user guidance and hands-free infrared draft shield, these micro and ultra-microbalances are incomparable in terms of accuracy and flexible use of tare vessels.

Mettler Toledo also provides tailored options and accessories; the micro weighing table enhances ergonomics for long-term weighing tasks; the balance-driven antistatic U-ionizer helps achieve more precise weighing results; and the new CarePac with up to three calibrated test weights ensures traceability of project results.

Mettler Toledo offers comprehensive solutions to comply with Food and Drug Administration's (FDA) and European regulations. Equipment Qualification (EQ) ensures the accuracy and consistency users require in equipment performance, and it covers all qualification steps (IQ, OQ, PQ, MQ).

METTLER TOLEDO can be found at www.mt.com.



Modal Shop Announces Hammer Calibration System

The Modal Shop, a PCB Group Company, announces a new impact hammer calibration system available as stand-alone or as an option to its industry leading 9155 accelerometer calibration workstation. The system includes the 9961C gravimetric calibration fixture which provides a calibrated pendulous mass to perform the dynamic impulse measurement. Using a precision PCB® reference accelerometer mounted on the calibrated pendulous mass, instrumented impact hammers such as the 086 line of ICP® impact hammers from PCB Piezotronics are quickly and easily calibrated with their variety of impact tips and extender masses.

As an option to The Modal Shop's accelerometer calibration workstation, the 9155D-961 impact hammer calibration system option integrates the pendulum hardware, reference transducers, and associated cabling with a 24-bit dynamic signal analyzer acquisition card and software that automates data acquisition, processing and reporting.

Using Microsoft Excel 2007 to generate calibration certificates, the user can easily modify the supplied template to create a customized presentation, such as adding a company logo or rearranging field order. This provides both corporate and regional independent metrology labs with the capability to support their accelerometer users who also commonly have instrumented impact hammers in their sensor asset inventory.

The option is the latest expansion available for the full-featured 9155 accelerometer calibration workstation. The modular 9155 platform supports the calibration of accelerometers and velocimeters, covering a range from 0.25 Hz to 50 kHz and 0.1 g to 10 kg, dependent upon the specific actuator.

Signal conditioning options support ICP®, charge, capacitive and piezo-resistive transducers.

The Modal Shop, Inc., www.modalshop.com, tel 800-860-4867, fax 513-458-2172, info@modalshop.com.

LaserLinc Announces Laser Scan Micrometer

LaserLinc, a manufacturer of non-contact, precision measurement systems, announces the release of a new laser scan micrometer, the TLAser130s. The TLAser130s is a compact, high-speed, single-axis model for wire, centerless ground parts, multi-strand measurement such as monofilament, and many other processes. Its non-contact, high-speed scanning is especially useful for flaw detection in small extruded products.

With its accuracy rating of up to ±.00004 inches, the TLAser130s is ideal for measuring diameter, detecting short defects, or profiling parts. It operates at a rate of 1600 measurements per second standard with an option of 4000 scans per second. The TLAser130s features a separate transmitter and receiver, similar to the TLAser122s, TLAser160s, and TLAser1120s. Its 30mm measurement window fills an important niche between the TLAser160s (60mm measurement window) and the smaller TLAser122s (22mm measurement window). The separate transmitter/receiver gives the unit versatility for products that require more horizontal room for measuring or more space below the scanner.

As with all LaserLinc scanners, the TLAser130s links—via the TLAser400™ micrometer interface card—to a PC running Total Vu™ software. Total Vu software is LaserLinc's sophisticated, yet operator-friendly, measurement/data processing package, which runs on any Windows-based PC, providing in-process tolerance checking, trending, SPC, feedback control, data logging, recipes, and other features.

LaserLinc, Inc., Robert Wexler, rwexler@laserlinc.com, tel 937-318-2440, toll-free 888-707-4852, www.laserlinc.com.

Testo Industrial Services Announces Pressure Calibrator

After the success of the mobile humidity generator Huminator, Testo Industrial Services (Kirchzarten, Germany) presents its new pressure calibrator – the Pneumator. The Pneumator can used as a calibrator or high-precision measuring device. The rugged design with its compact dimensions and long-time accumulator operation is perfect for mobile applications.

Besides its mobile use, the Pneumator is also at home in calibration labs, providing high precision in the low pressure range and high stability of zero-point, because of automatic calibration, fast supply of differential and relative pressure, as well as programmable pressure sequences characterize the device.

Its pressure sensor works absolutely nonwearing, is long-time stable and overload-proof. The Pneumator is available in 4 models with the pressure ranges 1, 10, 100 and 1.000 hPa.

Testo Industrial Services, GmbH, tel +49 7653 681-8000, fax +49 7653 681-8010, www.testo-industrial-services.com.

EDL Introduces MOV-1 Megaohm Validator

EDL, the makers of the FUR-1200 Calibration Furnace and Ultra Bath (stirred silicone oil or salt bath) line of calibrators, introduces the new Megaohm Validator®, a product that guarantees the measurement accuracy of insulation resistance testers. This product provides a simple method of ensuring insulation resistance testers are operating properly and within specification.

The MOV-1 was designed to make high resistance measurements. Many of these measurements are performed in the field using devices such as installation testers where ambient conditions can cause the user to question the validity of the measurement results. Polarization, moisture and poor insulation often result in erratic readings by the unit, causing doubt in the measurement.

The MOV-1 provides 6 high voltage capable resistant values (1M to 10G) with the accuracy and stability necessary for both onsite and laboratory requirements. This handheld device is housed in a protective case which makes it resilient and portable.

EDL, Inc. www.edl-inc.com

Quartzlock Announces GPS-Disciplined Rubidium Oscillator

After Quartzlock's successful launch of its E8 and E8000/8010 series Global Positioning System (GPS) disciplined Frequency and Time standards in 2009 we are pleased to announce our latest addition to this product range, the A10-GPS which is a compact, low-cost, low-power requirement GPS-disciplined rubidium oscillator for OEM manufacturing that provides the precision frequency and time synchronization required by base stations, optical network nodes, and high-speed digital networks.

The compact A10-GPS OEM products offer rubidium atomic standards which are disciplined to GPS, therefore providing extremely accurate and stable frequency and time. The rubidium standard is phase locked to the GPS or to the external 1PPS. All outputs are derived from the rubidium standard, which maintains the 10MHz and the 1PPS when GPS or external 1PPS inputs are interrupted.

A GPS-disciplined rubidium clock frees the user from being continuously dependent on GPS reception, particularly in cases of either intentional or unintentional GPS interruptions.

In Canada contact techniCAL at www.technical-sys.com or call 1-86-MEASURE-1 (1-866-327-8731).