CAL LAB

THE INTERNATIONAL JOURNAL OF METROLOGY

Good Metrology Practice (GMetP): Out-of-Tolerance Investigations

The Metrology of PCB Signal Integrity

Methods, Procedures, and Instructions

Badging for the Metrology Industry

2015
OCTOBER
NOVEMBER
DECEMBER

Electric Current Measurement

DS Series Current Transducers

±300A to ±8000A, high accuracy for Power Analyzers and improved performance for Power Amplifiers

- Very high absolute amplitude and phase accuracy from dc to over 1kHz
- Low signal output noise
- Low fluxgate switching noise on the pimary
- Enhanced electrostatic shielding to increase rejection of primary dV/dt coupling
- Increased operating temperature range
- Reduced mechanical dimensions
- Options: Voltage Output Signal; Calibration Winding
- Amplitude and Phase measurement to 300kHz included with each head

DS200

	DS200	DS600	DS2000	DS5000
Primary Current, rms	200A	600A	2000A	5000A
Primary Current, Peak	±300A	±900A	±3000A	±7000A
Turns Ratio	500:1	1500:1	1500:1	2500:1
Output Signal (rms/Peak)	0.4A/±0.6A†	0.4A/±0.6A†	1.33A/±2A†	2A/±3.2A†
Overall Accuracy	0.01%	0.01%	0.01%	
Offset	<20ppm	<10ppm	<10ppm	<5ppm
Linearity	<1ppm	<1ppm	<1ppm	<1ppm
Operating Temperature	-40 to 85˚C	-40 to 85˚C	-40 to 85˚C	0 to 55˚C
Aperature Diameter	27.6mm	27.6mm	68mm	150mm

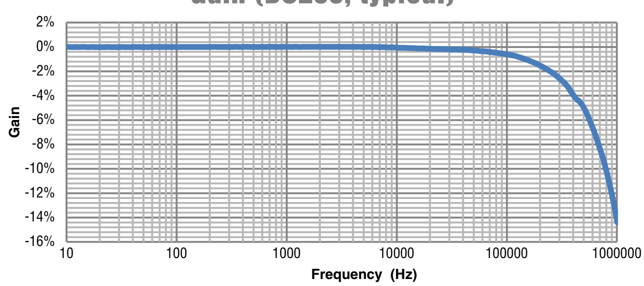
DS2000

Bandwidth Bands for Gain and Phase Error	DS200			DS600			DS2000			DS5000	
	<5kHz	<100kHz	<1MHz	<2kHz	<10kHz	<100kHz	<500Hz	<1kHz	<10kHz	<5kHz	<20kHz
Gain (sensitivity) Error	0.01%	0.5%	20%	0.01%	0.5%	3%	0.01%	0.05%	3%	0.01%	1%
Phase Error	0.2˚	4˚	30˚	0.1˚	0.5˚	3˚	0.01˚	0.1˚	1˚	0.01˚	1˚

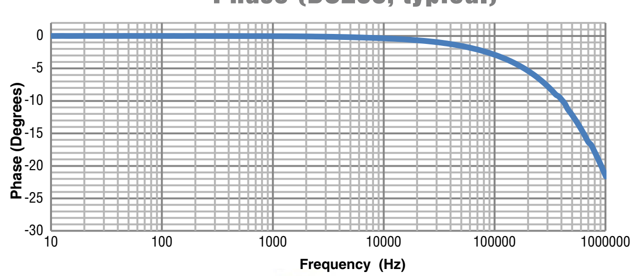
† Voltage Output options available in ±1V and ±10V

Gain / Phase

Gain (DS200, typical)



Phase (DS200, typical)



DSSIU-4 for Multi Channel Systems

4-channel Transducer Interface Unit and Power Supply improved performance for Power Amplifiers

- Power and Signal connections for up to four Current Transducer heads
- Heads may be mixed (e.g.: One DS2000 Head and three DS200 Heads)

DSSIU-4

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VOLUME 22, NUMBER 4

FEATURES

DEPARTMENTS

ON THE COVER: Engineer Liz Giraldo calibrating at the volume laboratory of "Instituto Nacional de Metrologia," the Colombian NMI in Bogotá.

UPCOMING CONFERENCES & MEETINGS

Dec 1-4, 2015 – 86th ARFTG Microwave Measurement Symposium. Atlanta, GA. An important part of all ARFTG conferences is the opportunity to interact with colleagues, experts and vendors in the RF and microwave test and measurement community. This event's theme is "Microwave Measurements with Applications to Bioengineering and Biomedicine." http://www.arftg.org.

Mar 21-23, 2016 FORUMESURE. Dakar, Senegal. Exhibition on Quality, Measurement, Accreditation and Instrumentation, This event is organized by The African Committee of Metrology (CAFMET). As the same time as the exhibition, the 6th International metrology Conference, CAFMET 2016, will take place. http://www.forumesure.com/.

Mar 21-24, 2016 International Metrology Conference. Dakar, Senegal. The African Committee of Metrology (CAFMET) is organizing the 6th International Conference of Metrology in Africa - CAFMET 2016, which will be a Metrology forum to share information, ideas and experiences, during conferences, open discussions, technical workshops and exhibition booths. http://www.cafmet2016.com/.

Mar 21-24, 2016 SSD-SCI International Conference on Sensors, Circuits and Instrumentation Systems. Leipzig, Germany. The International Conference on Sensors, Circuits and Instrumentation Systems (SCI) is a forum for researchers and specialists in different fields of electrical engineering related to sensors, circuits and instrumentation systems. http://www.ssd-conf.org/ssd16/index.php?site=index&conf=SCI.

Mar 23-25, 2016 Measurement Science Conference (MSC). Anaheim, CA. The 46th Measurement Science Conference will focus on embracing emerging approaches and technologies to address metrology while still supporting education in current standards, and legacy approaches. http://www.msc-conf.com.

Mar 29-31, 2016 European Flow Measurement Workshop. Noordwijk, The Netherlands. Hosted by VSL and CEESI, the most experienced engineers and specialized measurement institutes in flow measurement share with you their latest developments and challenges in flow metering systems and liquid flow. http://www.flowmeasurementworkshop.eu/.

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EDITOR'S DESK

Change of Season

Shortly after releasing the previous issue, Ken Parson, a contributor, died. Ken had spoken with me a couple months prior, right after a major health event. He felt an urgent need to share his articles during the limited time he had remaining. We thank Ken for allowing us to share his contributions with the measurement community. Many of you continue to be involved in the industry well after retirement and my hope is that each generation repeats this level of involvement in their later years.

❧

Father Time has announced a change of seasons. After a mild autumn, we are about to descend into cold… or wetness, depending on where you hang your hat. Chained to my desk, I will have to armchair travel to warmer climates, via Google. So, I made a quick trip to Colombia, from which our cover photo comes to us.

A couple years back, we started asking at conferences and on LinkedIn for laboratory cover photos with women. Though male-dominated, women do exist in our calibration labs and I'm pleased we've been able to represent them on our covers. This latest cover comes to us from Colombia's national metrology laboratory, Instituto Nacional de Metrologia, in Bogotá.

Our other contributors include: Phil Mistretta with his paper, "Good Metrology Practice (GMetP): Out-of-Tolerance Investigations," based on a popular webinar and presentation given last March at the Measurement Science Conference (MSC) in Anaheim, CA; Chris Grachanen, exploring common measurement methodologies used to validate circuit board designs in his article, "The Metrology of PCB Signal Integrity"; and Randy Long, who provides clarification on section 5.4 "Methods and method validation" of ISO/IEC 17025 in his article, "Methods, Procedures, and Instructions."

Happy Measuring,

Sita Schwartz

CALENDAR

May 2-5, 2016 ESTECH. Glendale, AZ. The 62th Annual Technical Meeting and Exposition of IEST, offers technical conference sessions, continuing education training courses, working group meetings, and exhibits in the fields of contamination control; design, test, and evaluation; product reliability; and nanotechnology. http://www.iest.org.

May 10-12, 2016 SENSOR+TEST. Nürnberg, Germany. Die Messtechnik-Messe, The Measurement Fair in Nürnberg is the world's leading forum for sensors, measuring and testing technology. http://www.sensor-test.com.

May 25-27, 2016 Milestones in Metrology V (MiM V). Amsterdam, Netherlands. Milestones in Metrology is the international metrology platform where manufacturers, end-users, regulators and metrological experts come together, exchange ideas and discuss the challenges of our field. http://milestonesinmetrology.nl/.

Jun 21-23, 2016 North American Custody Transfer Measurement Conference. San Antonio, TX. The conference will include all types of custody transfer measurement in addition to ultrasonic meter measurement. You will be able to hear speakers discuss a wide variety of fluid measurement issues and potential solutions. http://www.ceesi.com/SanAntonio2016.

Jul 10-15, 2016 Conference on Precision Electromagnetic Measurements (CPEM). Ottawa, Canada. Hosted by the National Research Council of Canada, this biennial conference is the premier international forum for the exchange of information on precision electromagnetic measurements. http://www.cpem2016.com.

SEMINARS: Automation

Feb 1-2, 2016 An Introduction to Instrument Control and Calibration Automation in LabVIEW™. Jacksonville, FL (NCSLI Technical Exchange). This two day hands-on tutorial will introduce session participants to the fundamental tools and concepts required to automate instrument control for calibration. http://www.ncsli.org.

SEMINARS: Dimensional

Nov 17-19 , 2015 Hands-On Gage Calibration. Aurora, IL. Mitutoyo Institute of Metrology. The Hands-On Gage Calibration course is active, hands-on and focused on the application of calibration procedures in the laboratory environment. http://www.mitutoyo.com/support/mitutoyo-institute-of-metrology/.

Dec 8-9, 2015 Hands-On Gage Calibration and Repair. Detroit, MI. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Dec 10-11, 2015 Hands-On Gage Calibration and Repair. Schaumburg, IL. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Dec 14-15, 2015 Hands-On Gage Calibration and Repair. Bloomington, MN. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Jan 27-28, 2016 Hands-On Gage Calibration and Repair. Las Vegas, NV. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Feb 2, 2016 Temperature Effects in Dimensional Metrology. Jacksonville, FL (NCSLI Technical Exchange). This tutorial provides a deeper discussion in selected topics in dimensional metrology. Topics that will be emphasized include thermal effects, design principles (which are also used in setting up measurements), and the principle behind various displacement transducers. http://www.ncsli.org

Feb 9-11, 2016 Hands-On Gage Calibration. Aurora, IL. Mitutoyo Institute of Metrology. The Hands-On Gage Calibration course is active, hands-on and focused on the application of calibration procedures in the laboratory environment. http://www.mitutoyo.com/support/mitutoyo-institute-of-metrology/.

Feb 10-11, 2016 Hands-On Gage Calibration and Repair. Akron, OH. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Mar 8-9, 2016 Hands-On Gage Calibration and Repair. Chicago, IL. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Mar 16-17, 2016 Hands-On Gage Calibration and Repair. Blaine, MN. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Apr 6-7, 2016 Hands-On Gage Calibration and Repair. Portland, OR. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Apr 27-28, 2016 Hands-On Gage Calibration and Repair. Atlanta, GA. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

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CALENDAR

May 18-19, 2016 Hands-On Gage Calibration and Repair. Colorado Spring, CO. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

SEMINARS: Electrical

Nov 16-19, 2015 MET-301 Advanced Hands-on Metrology. Everett, WA. Fluke Calibration. This course introduces the student to advanced measurement concepts and math used in standards laboratories. http://us.flukecal.com/training/courses/MET-301.

Apr 11-14, 2016 MET-101 Basic Hands-on Metrology. Everett, WA. Fluke Calibration. This course introduces the student to basic measurement concepts, basic electronics related to measurement instruments and math used in calibration. http://us.flukecal.com/training/courses/MET-101.

Apr 18-21, 2016 MET-301 Advanced Hands-on Metrology. Everett, WA. Fluke Calibration. This course introduces the student to advanced measurement concepts and math used in standards laboratories. http://us.flukecal.com/training/courses/MET-301.

SEMINARS: Flow & Pressure

Feb 1, 2016 Flow Measurements and Uncertainties. Jacksonville, FL (NCSLI Technical Exchange). Methods of flow meter calibration used in laboratory, including NIST standards will be covered. Field conditions will be discussed as well as installation effects and how distorted velocity profiles affect flowmeter accuracy. Flow calculations and uncertainty analyses for certain flow meter types will be taught. http://www.ncsli.org.

Apr 11-15, 2016 Advanced Piston Gauge Metrology. Phoenix, AZ. Fluke Calibration. Focus is on the theory, use and calibration of piston gauges and dead weight testers. http://us.flukecal.com/Advanced-Piston-Gauge-Metrology.

Apr 18-22, 2016 Principles of Pressure Calibration. Phoenix, AZ. Fluke Calibration. A five day training course on the principles and practices of pressure calibration using digital pressure calibrators and piston gauges (pressure balances). http://us.flukecal.com/Principles-of-Pressure.

SEMINARS: General & Management

Nov 20, 2015 Root Cause Analysis and Corrective Action (RCA/CA). Savannah, GA. A2LA. Presentations, discussions and exercises that provide an in-depth understanding of how to analyze a system in order to identify the root causes of problems and to prevent them from recurring. http://www.a2la.org/training/rootcause.cfm?private=no.

Dec 7-11, 2015 Fundamentals of Metrology. Gaithersburg, MD. NIST. The Fundamentals of Metrology seminar will introduce the participant to the concepts of measurement systems, units, measurement uncertainty, measurement assurance, traceability, basic statistics and how they fit into the laboratory Quality Management System. http://www.nist.gov/pml/wmd/5392.cfm.

Dec 8-10, 2015 Cal Lab Manager Training; Beyond 17025. Los Angeles CA - Transcat (Fullerton). WorkPlace Training. This course is designed for new lab managers, and for experienced managers who would like to learn how modern labs meet the challenge of satisfying greater customer demand with ever-diminishing lab resources. http:// www.wptraining.com .

Jan 25-29, 2016 Fundamentals of Metrology. Gaithersburg, MD. NIST. The Fundamentals of Metrology seminar will introduce the participant to the concepts of measurement systems, units, measurement uncertainty, measurement assurance, traceability, basic statistics and how they fit into the laboratory Quality Management System. http://www.nist.gov/pml/wmd/5377.cfm.

Feb 2, 2016 Conducting an Effective Internal Audit. Jacksonville, FL (NCSLI Technical Exchange). This tutorial will explore the concept of internal auditing and its benefits. During the course, the participants will learn various auditing techniques and practice application of these techniques. http://www.ncsli.org.

Feb 2, 2016 Stating Compliance to Specifications with Confidence: In-Tolerance, Out-of-Tolerance, Indeterminate and Guardbanding. Jacksonville, FL (NCSLI Technical Exchange). This tutorial provides an overview of Metrology terms and concepts such as measurement uncertainty and traceability and provide an introduction to measurement decision risk. http://www.ncsli.org.

Feb 22-26, 2016 Fundamentals of Metrology. Gaithersburg, MD. NIST. The Fundamentals of Metrology seminar will introduce the participant to the concepts of measurement systems, units, measurement uncertainty, measurement assurance, traceability, basic statistics and how they fit into the laboratory Quality Management System. http://www.nist.gov/pml/wmd/5378.cfm.

Apr 4-8, 2016 Fundamentals of Metrology. Gaithersburg, MD. NIST. The Fundamentals of Metrology seminar will introduce the participant to the concepts of measurement systems, units, measurement uncertainty, measurement assurance, traceability, basic statistics and how they fit into the laboratory Quality Management System. http://www.nist.gov/pml/wmd/5380.cfm.

Apr 12-14, 2016 Cal Lab Manager Training; Beyond 17025. Boca Raton – WPT/QSL Training Academy. WorkPlace Training. This course is designed for new lab managers, and for experienced managers who would like to learn how modern labs meet the challenge of satisfying greater customer demand with ever-diminishing lab resources. http:// www.wptraining.com .

SEMINARS: Industry Standards

Nov 18-19, 2015 ISO/IEC 17025:2005 and Laboratory Accreditation. Savannah, GA. A2LA. This course is an introductory look at ISO/IEC 17025 and its requirements for demonstrating the technical competence of testing and calibration laboratories. http://www.a2la.org/training/iso17025.cfm?private=no.

Dec 2-3, 2015 ISO/IEC 17025:2005 and Laboratory Accreditation. Frederick, MD. A2LA. This course is an introductory look at ISO/IEC 17025 and its requirements for demonstrating the technical competence of testing and calibration laboratories. http://www.a2la.org/training/iso17025.cfm?private=no.

December 7-11, 2015, ISO/IEC 17025 Lead Assessor Training. St. Petersburg, FL. ANAB. This 4.5 day course will enable attendees to develop a solid understanding of the ISO/IEC 17025 standard and be able to plan and lead an ISO/IEC 17025 assessment. http://anab.org/training/

Feb 1, 2016 ISO/IEC 17025 Laboratory Accreditation. Jacksonville, FL (NCSLI Technical Exchange). This course is a comprehensive look at ISO/IEC 17025 and its documentation and internal auditing requirements. http://www.ncsli.org.

Feb 1, 2016 Proficiency Testing. Jacksonville, FL (NCSLI Technical Exchange). This tutorial will focus on the technical aspects of proficiency testing. Technical requirements from ISO/IEC 17043:2010 will be covered. http://www.ncsli.org.

SEMINARS: Mass & Weight

Jan 19-21, 2016 Balance and Scale Calibration & Uncertainties. Gaithersburg, MD. NIST Office of Weights and Measures. This NIST Seminar will cover the calibration and use of analytical weighing instruments (balances and laboratory/bench-top scales), including sources of weighing errors in analytical environments, methodologies for quantifying the errors, and computation of balance calibration uncertainty and global (user) uncertainty. http://www.nist.gov/pml/wmd/5397.cfm.

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Feb 2, 2016 Fundamentals of Force Calibration. Jacksonville, FL (NCSLI Technical Exchange). This course will cover the importance of calibrating force measurement devices in the manner in which they are being used to reduce measurement errors and lower uncertainty. http://www.ncsli.org.

Feb 2, 2016 Good Weighing Practices. Jacksonville, FL (NCSLI Technical Exchange). During this session, we will break down how measurement uncertainty exhibits itself, across the capacity of an electronic balance. We will cover how to correctly assess and assign a weighing tolerance, before discussing the phenomena that affect the accuracy of weighing, to illustrate how easy it is to create poor weight data! To contrast this, you will learn how to overcome these potential sources of error, and optimize a balance metrology regime. http://www.ncsli.org.

Mar 7-18, 2016 Mass Metrology Seminar. Gaithersburg, MD. NIST Office of Weights and Measures. The Mass Metrology Seminar is a two-week, "hands-on" seminar. It incorporates approximately 30 percent lectures and 70 percent demonstrations and laboratory work in which the trainee performs measurements by applying procedures and equations discussed in the classroom. Successful completion of the Fundamentals of Metrology Seminar is a prerequisite for the Mass Metrology Seminar. http://www.nist.gov/pml/wmd/5379.cfm.

May 16-27, 2016 Mass Metrology Seminar. Gaithersburg, MD. NIST Office of Weights and Measures. The Mass Metrology Seminar is a two-week, "hands-on" seminar. It incorporates approximately 30 percent lectures and 70 percent demonstrations and laboratory work in which the trainee performs measurements by applying procedures and equations discussed in the classroom. Successful completion of the Fundamentals of Metrology Seminar is a prerequisite for the Mass Metrology Seminar. http://www.nist.gov/pml/wmd/5381.cfm.

SEMINARS: Measurement Uncertainty

Nov 16-17, 2015 Introduction to Measurement Uncertainty. Savannah, GA. American Association for Laboratory Accreditation, http://www.a2la.org/training/course_schedule.cfm.

Jan 12-13, 2016 Measurement Uncertainty (per ILAC P14 Guidelines). Puerto Rico. WorkPlace Training. This workshop introduces basic measurement uncertainty and traceability concepts. The concepts taught are then put in practice by developing sample measurement uncertainty budgets. http://www.wptraining.com.

Feb 1, 2016. Calculating Uncertainties in Testing Laboratories. Jacksonville, FL (NCSLI Technical Exchange). This workshop will cover many aspects of estimating the measurement uncertainty for a testing laboratory, including the finer aspects of data analysis for developing measurement uncertainty budgets using the GUM approach. http://www.ncsli.org.

Feb 2, 2016 Statistical Analysis of Metrology Data. Jacksonville, FL (NCSLI Technical Exchange). This is a full-day, beginner to intermediate level workshop targeted towards metrologists, technicians and engineers. http://www.ncsli.org.

Feb 9-10, 2016 Measurement Uncertainty (per ILAC P14 Guidelines). Houston, TX. WorkPlace Training. This workshop introduces basic measurement uncertainty and traceability concepts. The concepts taught are then put in practice by developing sample measurement uncertainty budgets. http://www.wptraining.com.

Mar 21-22, 2016 Measurement Uncertainty (per ILAC P14 Guidelines). Fullerton, CA (precedes MSC). WorkPlace Training. This workshop introduces basic measurement uncertainty and traceability concepts. The concepts taught are then put in practice by developing sample measurement uncertainty budgets. http://www.wptraining.com.

SEMINARS: RF Microwave

Feb 1, 2016. Understanding RF Power Sensor Calibrations. Jacksonville, FL (NCSLI Technical Exchange). This one day workshop provides a practical introduction to RF power transfer between two coupled ports with discussions on key components and methods. http://www.ncsli.org

Feb 2, 2016. RF Microwave Basics. Jacksonville, FL (NCSLI Technical Exchange). An introduction to the measurement concepts for microwave power and scattering-parameters will be covered. http://www.ncsli.org

SEMINARS: Software

Dec 14-18, 2015 Basic MET/CAL® Procedure Writing. Everett, WA. Fluke Calibration. In this five-day basic MET/CAL procedure writing course, you will learn to configure MET/CAL software to create, edit, and maintain calibration solutions, projects and procedures. http://us.flukecal.com/software-training.

Feb 29-Mar 4, 2016 Basic MET/CAL® Procedure Writing. Everett, WA. Fluke Calibration. In this five-day basic MET/CAL procedure writing course, you will learn to configure MET/CAL software to create, edit, and maintain calibration solutions, projects and procedures. http://us.flukecal.com/software-training.

Apr 25-29, 2016 Advanced MET/CAL Procedure Writing. Everett, WA. This five-day in-depth workshop is for experienced MET/CAL programmers who wish to enhance their procedure writing skills. Students will focus on the use of instrument communication with the IEEE, PORT, VISA, MATH and LIB FSCs, the use of memory registers in procedures, and will create a complex procedure using live instrumentation. http://us.flukecal.com/software-training.

SEMINARS: Temperature

Feb 1, 2016 Infrared Thermometry. Jacksonville, FL (NCSLI Technical Exchange). This tutorial is an overview of industrial level application of radiation and infrared thermometry, geared to those who are new to radiation thermometer measurement, engineers designing processes, those who need a refresher on the subject, and to those who would like to make better measurements. http://www.ncsli.org.

CALENDAR

Feb 1, 2016 Industrial Platinum Resistance Thermometry. Jacksonville, FL (NCSLI Technical Exchange). In this seminar, we will discuss contact thermometers commonly used in industry for applications that use industrial platinum resistance thermometers including digital thermometers. http://www.ncsli.org.

Apr 12-14, 2016 Advanced Topics in Temperature Metrology. American Fork, UT. Fluke Calibration. A three-day course for those who need to get into the details of temperature metrology, including ITS-90 calibration, process design, curve fitting, uncertainty analysis, and advanced procedures for reducing uncertainties. http://us.flukecal.com/tempcal_training.

SEMINARS: Vibration

Nov 30-Dec 2, 2015 Fundamentals of Vibration for Test Applications. Las Vegas, NV. Technology Training Inc. This course covers a wide range of topics associated with vibration and shock applications in order to enable the course participants to acquire a basic understanding of the complex field of vibration and shock. http://www.ttiedu.com.

Feb 16-18, 2016 Fundamentals of Random Vibration and Shock Testing. Santa Barbara, CA. A review of basic vibrations, sources and causes, followed by an exploration of vibration measurements, analysis and calibration. http://www.equipment-reliability.com.

SEMINARS: Volume

Jun 13-17, 2016 Volume Metrology. Gaithersburg, MD. NIST Office of Weights and Measures. The volume metrology seminar is designed to enable metrologists to apply fundamental measurement concepts to volume calibrations. Prerequisites: Fundamentals of Metrology and Mass Metrology. http://www.nist.gov/pml/wmd/5398.cfm.

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AC-DC Metrology– Self-Paced Online Training. Fluke Training. Learn the basic concepts of ac/dc metrology, including the theory and application of thermal transfer standards to measure ac voltages and currents, definition of inductance and capacitance, and the measurement of impedance, admittance and immittance. http://training.fluke.com/Courses.htm.

ASQ CCT Exam Preparation Program. Learning Measure. This program contains courses that cover all aspects of the ASQ Certified Calibration Technician exam body of knowledge. http://www.learningmeasure.com/.

Basic Antenna Measurement Program. Learning Measure. This program covers concepts associated with basic antenna measurements. http://www.learningmeasure.com/.

Basic Dimensional Measurement Tools – Self Directed Learning. QC Training. With this program, workers will master the essentials of handling, applying and reading the most common gages on today's shop floors – from steel rules to micrometers and height gages. http://www.qcgroup.com/sdl/.

Basic Mass Computer-Based Training. NIST Weights and Measures Laboratory Metrology Program. Free download available in English and Spanish. http://www.nist.gov/pml/wmd/labmetrology/training.cfm.

Basic Measurement Concepts Program. Learning Measure. This program introduces basic measurement concepts, the SI system of units, and measurement uncertainty analysis. http://www.learningmeasure.com/programs.shtml.

Basic RF & Microwave Program. Learning Measure. This is an introductory program covering the RF and microwave measurement field. http://www.learningmeasure.com/.

Certified Calibration Technician Certification Preparation - Web-Based. ASQ. This self-paced course covers the material you will see on the CCT exam. It includes a practice test based on the CCT Body of Knowledge. http://asq.org/training/catalog/delivery/self-paced.html.

Certified Calibration Technician – Self-study Course. J&G Technology has developed a self-study course to assist you in passing the ASQ CCT exam. http://www.jg-technology.com/selfstudy.html.

Certified Calibration Technician Prep – Online. QC Training. Using the same materials used in our 3-day classroom training, students prepare for ASQ"s examination for Certified Calibration Technician. http://www.qcgroup.com/online/.

Electronics for Non-Electronic Engineers – OnDemand Complete Internet Course. Technology Training, Inc. (TTI). To help participants to understand the concepts and terminology of electronics. http://www.ttiedu.com/.

Introduction to Measurement and Calibration – Online Training. QC Training. An easy to access, menu driven curriculum allows the learner to concentrate on the topics specific to their job requirements. For anyone taking measurements, new hires, students or a refresher for technicians. http://www.qcgroup.com/online/.

Introduction to Measurement and Calibration – Self-Paced Online Classes. Fluke Calibration. This course instructs the user on basic concepts of measurement and calibration. http://training.fluke.com/Courses.htm.

Introduction to Measurement and Calibration - Web-Based. ASQ. Satisfy the requirements for ISO 17025 and 16949, FDA,and FAA. You will learn skills including standardization, managing a metrology system, and units and instrumentation of measurements. http://asq.org/training/catalog/delivery/self-paced.html.

Introduction to Metrology - e-Learning. NPL. This course has been designed to introduce metrology, the science of measurement, and explore its value for industry, the economy, science and society. http://www.npl.co.uk/training.

Instrumentation for Test and Measurement – OnDemand Complete Internet Course. Technology Training, Inc. (TTI). Course 163 presents basic information on selection, application, calibration and usage of modern measurement systems to measure electrical, environmental and dynamic phenomena. http://www.ttiedu.com/.

ISO/IEC 17025 Compliance. WorkPlace Training, tel (612) 308-2202, info@wptraining.com, http://www.wptraining.com/.

Measurement Uncertainty – Self-Paced Online Training. Fluke Training. Learn the fundamental concepts and how to successfully determine measurement uncertainty and quality improvement techniques. http://training.fluke.com/Courses.htm.

Measurement Uncertainty Analysis – Online Training. The QC Group. Targeted for calibration technicians, quality managers, engineers, quality technicians, and other users of uncertainty budgets. http://www.qcgroup.com/online/.

Metrology for Cal Lab Personnel – Self-Paced Online Training. Fluke Training. A general overview of metrology principles and practices; designed to help calibration laboratory personnel prepare for the American Society of

Quality (ASQ) Certified Calibration Technician examination. http://training.fluke.com/Courses.htm.

Metrology Concepts. QUAMETEC Institute of Measurement Technology. This category contains courses designed to teach the basics that are needed for a well rounded understanding of Metrology. http://www.QIMTonline.com.

Metrology Concepts – OnDemand Complete Internet Course. Technology Training, Inc. (TTI). Provides a basic understanding of the wide range of activities encompassed by personnel working in standards and calibration laboratories. http://www.ttiedu.com/.

Precision Measurement Series Level 1 & 2. WorkPlace Training, http://www.wptraining.com/.

Precision Electrical Measurement – Self-Paced Online Training. Fluke Training. This course will increase your knowledge of terminology, concepts and procedures to help you become more proficient. http://training.fluke.com/Courses.htm.

Precision Dimensional Measurement – Online. QC Training. Advance your career with a low-cost, online course in precision dimensional measurement, tools and techniques. http://www.qcgroup.com/online/.

Vibration and Shock Testing. Equipment Reliability Institute. Power Point text and photo slides plus animations and video clips teach you about vibration and shock basics, control, instrumentation, calibration, analysis and sine and random vibration testing, as well as ESS, HALT and HASS. http://equipment-reliability.com/training/distance-learning/.

The Uncertainty Analysis Program. Learning Measure. This program covers all the courses concerning uncertainty and uncertainty analysis. http://www.learningmeasure.com/.

Do you offer Online Learning you want us to know about?
Email **office@callabmag.com.**

Quality Professional Passes Away

January 23, 1934 – October 1, 2015

Kenneth N. Parson passed away peacefully at his home in Port Ludlow, Washington, surrounded by family. He is survived by his wife of 62 years, Joanna; sons, Phil, Gary, and Ray; daughter, Teri; eight grandchildren and nine great-grandchildren.

Born in Edmonton, Canada, he later moved to Vallejo, California. At just 16 years old, he earned his pilot's license. He met Joanna while they were seniors in high school and married a year later. He joined the US Air Force in 1953 and served four years. He then moved the family to Poulsbo, Washington in 1965 and worked at the Naval Submarine Base at Bangor in laboratory quality management until 1989.

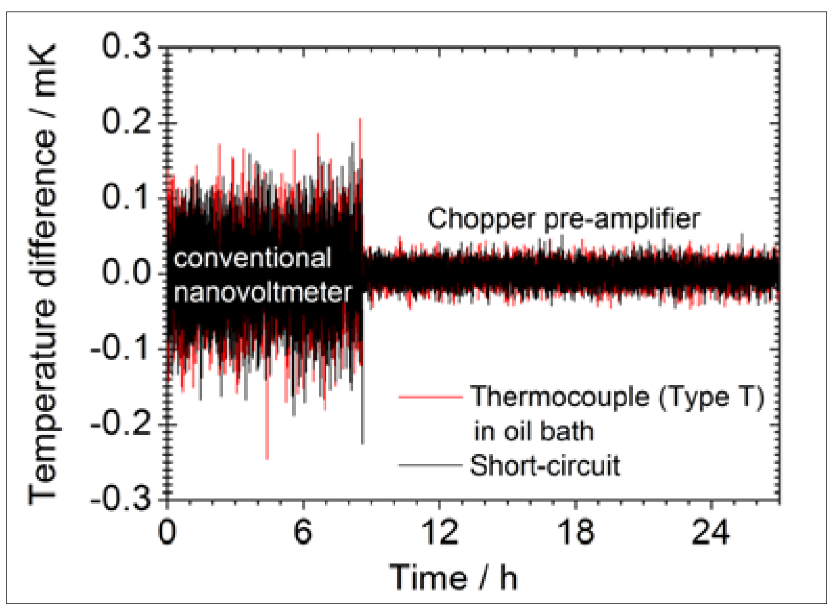
After retiring from Bangor, Ken continued to be involved in laboratory quality management and accreditation with NVLAP as a consultant for another 20 years. During this time, he also earned his MBA from Pepperdine University in 1991. After 2010, he focused his attention to documenting his years of knowledge. He published a book, *Laboratory Quality Management: A Workbook with an Eye on Accreditation*, and contributed several articles to *Cal Lab* magazine. He was known to those he worked with as a truly dedicated metrologist.

Outside his professional life, he was a pilot and loved to fly. Ken also loved photography; hosting parties; cooking and; best of all, his wife and family. As a friend, he was warm and kind. We'll miss you Ken.

PTB Chopper-Stabilized Amplifier

To measure small DC voltages, PTB has developed a chopper-stabilized amplifier with excellent properties. The amplifier exhibits very fast settling and an extremely low voltage noise of only 0.73 nV/√Hz down to frequencies of a few millihertz. At the typical chopping frequency of 570 Hz, a current noise of 40 fA/√Hz with a 1/f corner frequency of 3 mHz is achieved. This amplifier had originally been designed as a null detector for the cryogenic current comparators developed by PTB, but the instrument is also very well suited for other demanding metrological applications such as high-precision voltage measurements on thermocouples.

For the redefinition of the Avo-gadro constant, the ratio of the volume of a silicon sphere to the volume of the unit cell of the silicon crystal must be determined. Special interferometers are used in vacuum to measure each of these two geometrical quantities with relative uncertainties lower than 10^{-9}. Due to the low thermal expansion coefficient of approx. $2.5 \cdot 10^{-6}\ K^{-1}$, the temperature of the silicon sphere must be measured accurately to a millikelvin or better. For this purpose, thermocouples – in combination with a platinum resistance thermometer – are used which, due to their small dimensions, can be mounted very flexibly on the test sample and, in addition, exhibit no self-heating. With approx. 40 μV/K, such thermocouples, however, have very poor sensitivity, which represents a considerable challenge when measuring the thermoelectric voltages. In this measurement set-up, the chopper-stabilized amplifier has now been used as a low-noise pre-amplifier – compared with the previously used commercial nano-voltmeter. The figure shows the results of a measurement series where the difference in the thermoelectric voltages has been measured in the two junctions of the thermocouple. According to these results, using the chopper-stabilized amplifier reduces the noise amplitude by a factor of 4. Aiming for the same measurement



Measurement of the thermoelectric voltage difference across both junctions of a thermocouple, represented as the corresponding temperature difference (red curve). At a constant temperature difference, the result expected would be similar to the measurement of a short circuit (plotted here as a black curve for comparison purposes). Using the chopper-stabilized pre-amplifier (in the diagram after 8.5 hours) causes the noise amplitude to decrease by a factor of approx. 4, down to effectively 0.1 mK (peak to peak).

uncertainty, the chopper-stabilized amplifier thus enables the measuring time to be reduced by at a factor of 16, alternatively. At the same measuring time, the measurement uncertainty achieved is four times smaller.

Contact

Dietmar Drung, Department 7.2, Cryophysics and Spectrometry, Phone: +49 (0)30 3481-7342, E-mail: dietmar.drung(at)ptb.de.

Scientific Publication

D. Drung, J.-H. Storm: Ultra-low noise chopper amplifier with low input charge injection. *IEEE Trans. Instrum. Meas.* 60, 2347-2352 (2011)

Source: PTB-News 2.2015, *http://ptb.de.*

Inauguration of the Postgraduate Institute for Measurement Science

As part of the new strategic partnership between the National Physical Laboratory (NPL) and the Universities of Surrey and Strathclyde, a new institute has been established. Inaugurated on Friday 23 October 2015, the Postgraduate Institute for Measurement Science aims to be the premier UK and international centre for doctoral training and skills development in metrology and metrological applications.

With tailored metrology-focused training programs, that complement the skills training provided by their host Universities, the students will be part of a high-value cohort experience in innovative research within the National Measurement System to provide the measurement capability that underpins the UK's prosperity and quality of life.

The institute was inaugurated by Dr David Grant, Chair of the NPL Board, and included a presentation to the Postgraduate Institute Ambassadors in recognition of their importance in creating and maintaining a strong voice for the postgraduate community. In addition, the role of these Ambassadors will bring together the postgraduate researchers at a variety of social and scientific events to provide a unique insight into the wider impact of metrology and its applications.

A key aim of the Postgraduate Institute is to create a strong cohort experience for the more than 150 postgraduate researchers co-supervised by NPL staff. With the provision of a coherent training plan and an infrastructure that supports the delivery of scientific and social events, the postgraduates will emerge with

enhanced skills and abilities that will improve their prospects and position them well for future employability in the field of measurement science.

The inauguration ceremony was preceded by several presentations and a laboratory tour of the Time & Frequency, Quantum Detection and Electromagnetics Groups at NPL, organised by the Postgraduate Institute Ambassadors, which provided a comprehensive view of the work that takes place within these scientific areas. This event was organised for the benefit of the postgraduates and included a talk by broadcaster and University of Surrey Professor Jim Al-Khalili, who reflected on how valuable a Postgraduate Institute would have been to his own career.

The Postgraduate Institute also received strong support from local MP Dr Tania Mathias, who requested to meet some of the postgraduate students to discuss their PhD research and showed a great interest in the scientific work presented.

The inauguration event was attended by more than 150 delegates consisting of postgraduate researchers based at NPL, as well as their associated academic and NPL supervisors. In addition, there were invited guests from NPL's strategic and framework partnership universities, and directors from the NPL-supported EPSRC Centres for Doctoral Training, as well as relevant institutes and industry with whom NPL has ongoing partnership and engagement.

Find out more about the Postgraduate Institute for Measurement Science, visit: http://www.npl.co.uk/pgi/.

Source: http://www.npl.co.uk/news/inauguration-of-the-postgraduate-institute-for-measurement-science.

Fundamental Constants: The Latest . . . and the Last?

October 26, 2015—In a world of incessant change, some things have to stay the same. One is the set of values for the fundamental physical constants – such as the speed of light or the charge of the electron – that underlie precision measurements in industry, science, and medicine worldwide.

Yet even the constants themselves occasionally change incrementally to reflect the latest experimental determinations. So by international agreement,* a new set of official suggested values is published every four years, and NIST is now displaying the most recent (the 2014 values, published a few weeks ago) on its website.

The quadrennial list rarely generates headlines, but the 2014 values are remarkable in the context of the planned redefinition of the SI base units in 2018.

Several years ago, the international General Conference on Weights and Measures (CGPM) – the diplomatic body that has the authority under the Meter Convention to enact such a sweeping change – approved a plan to redefine four of the seven SI base units** in terms of fixed values of fundamental constants. Those values would be fixed at the most accurate values obtainable at the time of redefinition.

But CGPM placed strict preconditions and technical requirements for agreement and uncertainties in those measurements, and the 2010 values of two key constants did not meet those criteria. For example, CGPM had called for determinations of the Planck constant (h, used to redefine the kilogram) that had relative uncertainties of 20 parts per billion (ppb) and were consistent between two physically different methods of measurement. The 2010 value had a relative uncertainty of 43 ppb.

Thanks in large measure to painstaking efforts by scientists in NIST's Physical Measurement Laboratory (PML) to investigate, reanalyze, and refit NIST's workhorse watt balance, the latest values for h have a combined relative uncertainty of 12 parts ppb – a three-fold improvement since the 2010 values – and are consistent among three different laboratories in three countries. The 2014 values also include a determination for the Boltzmann constant (used to define the kelvin) that substantially exceeds CGPM's relative uncertainty criteria.

Other highlights of the 2014 values include a ten-fold improvement in the uncertainty in the mass of the electron, and significant improvement in the magnetic moment of the proton.

"The 2014 CODATA recommended values of the constants reflect improvements in measurements that allow the redefinition of the SI anticipated for 2018 to be on track," says Peter Mohr, Manager of the Fundamental Constants Data Center in PML. "If things go as planned, this will be the last official set of fundamental constants based on the SI as it is now defined. After 2018 there will be new recommended values based on the new SI that will have significantly smaller uncertainties in most cases."

* The values are determined and issued by the Task Group on Fundamental Constants of the International Council for Science's Committee on Data for Science and Technology (CODATA), which collects the best determinations from academic laboratories, independent standards laboratories, and national metrology institutes. The United States is one of 23 member nations.

** The kilogram, kelvin, ampere, and mole will be redefined in terms of the Planck constant, the Boltzmann constant, the charge of the electron, and the Avogadro constant.

Source: NIST Physical Measurement Laboratory, Quantum Measurement Division (http://nist.gov/pml/div684/2014-codata-values-posted.cfm).

Trescal Opens Cal Lab in Casablanca, Morocco

Casablanca, October 22nd 2015—Trescal, the global specialist in calibration services, has opened a new site in Casablanca to address the needs of industrial clients in Morocco and in Africa. The opening of a new calibration laboratory is part of the Group's strategy to expand into new territories, whilst continuing to support existing customers and their calibration needs wherever they may be in the world - through the provision of proximity services offering greater reactivity and flexibility.

The Casablanca laboratory (310m²) offers multi-domain calibration services and holds specific technical skills across:

- Electricity-Magnetism LF and microwave, Time / Frequency
- Climatic : climatic and thermostatic chambers, ovens, baths
- Physical measurements: Temperature, Humidity, Torque, Pressure, Scale
- Mechanical : gauges and hand tools

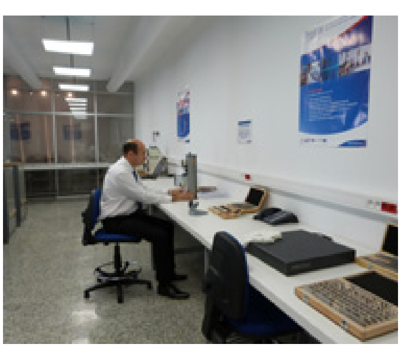
Further investment is planned to increase production capacity and the technical parameters of the laboratory.

The Casablanca laboratory benefits from an extensive global network of technical expertise, which will enable its customers to access skills and services of a very high quality.

The services will be carried out on site and in laboratories initially, by a team of 5 people with plans to increase this number in the coming months.

JL. Richard, Director of the Casablanca laboratory, declared, "Our laboratory is located close to major industrials customers, especially in the aeronautic sector, which represent more than half of the group's business. Many industrial companies were interested in our plans to set up a Trescal laboratory in Morocco, today it's done."

The creation of this new laboratory has represented an investment of over 3.5 million dirhams for Trescal. Trescal laboratory is located Zone Indusparc - Sidi Moumen- tertiary Path 1015- 20400 Casablanca. For further information about Trescal Casablanca: maroc@trescal.com.



NIST Calibrates Quartz Crystals

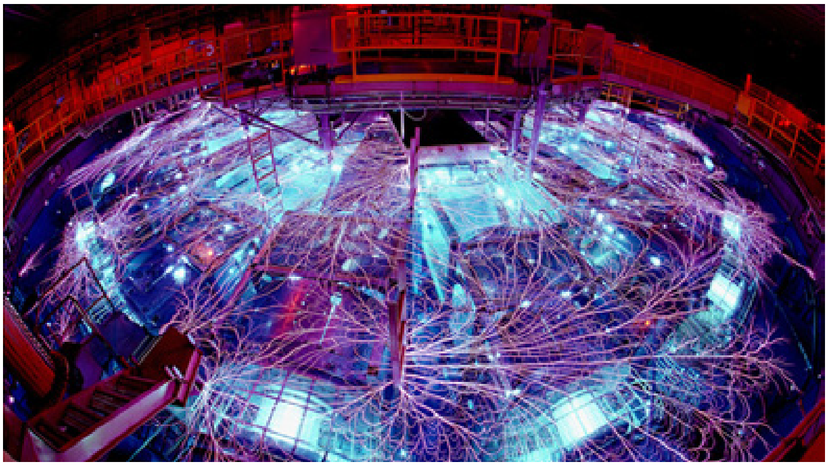
September 29, 2015—Last spring, PML's x-ray calibration facilities were used in a pinch – a Z pinch, that is.

The Sandia National Laboratories' Z Pulsed Power Facility, or "Z machine," a nuclear fusion research device located in Albuquerque, New Mexico, is the most powerful x-ray generator in the world. In bursts of energy each lasting a few billionths of a second, the Z machine produces the hottest matter available on Earth, matter similar to that produced inside a star.

The facility's style of fusion, which uses the "Z pinch" method (more on that below), is used for a range of studies, including the development of fusion energy applications and understanding how stars work.

Detectors inside the Z machine record what happens during each fusion event in as much detail as possible. And specialized x-ray optics called "bent quartz crystals" are a key part of diagnosing those signals.

In a collaboration among PML's Radiation Physics Division, Artep Inc., and Sandia National Laboratories, a set of 18 bent quartz crystals had their energy and sensitivity responses calibrated at NIST's campus in Gaithersburg, Md., earlier this year. The curved crystals are designed to extend the energy range of the x rays that can be measured when emitted by Sandia's Z machine.



The Sandia Z machine. Credit: Sandia National Laboratories. Photo by Randy Montoya.

Bent quartz crystals are literally that: thin, rectangular slabs of the mineral quartz, about the length and width of a bar of soap but only 0.2 mm thick, spring-loaded into metal holders that force them to maintain their curvature. "There is a science and art to bending crystals, and we are one of the world's leaders in that area," says PML's Lawrence Hudson, who led the organization of the team that performed the calibrations.

The crystals are sensitive to hard x rays, within the spectral range of 10 keV to 100 keV, though their sensitivity within that range depends on how they were cut.

"These newly bent quartz crystals are similar to what we have been using with the Z machine before," says Sandia Labs' Guillaume Loisel, who hand-carried the crystals to Sandia after the testing, evaluation, and calibrations at NIST. "But we are using a new set of crystal cuts, or orientations, that are sensitive to a band of x-ray frequencies that haven't been observed accurately on the Z machine to date."

The purpose of the bent quartz is to disperse x-ray light. To an incoming x ray of the correct frequency, these optics act like prisms, causing the radiation to fan out into a sort of "x-ray rainbow," Hudson explains. Those dispersed rays then pass into a detector that records the frequency and intensity of that light. By spatially separating the frequencies from each other, the crystals allow detectors to pick up more subtle differences in the spectral signatures coming out of fusion events.

However, each crystal has its own energy response. Calibrating how these optics transmit x rays of different energies ensures that researchers can determine the original emitted spectrum from the detected spectrum.

CAL-TOONS by Ted Green teddytoons@me.com

The team performed two types of calibrations on the crystals to gauge their response to energy and intensity. For the energy measurements, they exposed the crystals to continuous-spectrum x rays from a tungsten x-ray source, and used filters to create "notches" in this spectrum – that is, to lower the intensity of key bands of frequency whose energy positions are well-known.

Gauging the optics' sensitivity to x rays of different energies required a second setup, involving an x-ray source passing through a combination of filters which created a known spectral shape. PML scientist Michelle O'Brien quantified the intensity of the x rays by measuring them with the national standard for assessing radiation exposure. NIST staff then compared the radiation exposure measured with the national standard to the exposure of a detector collecting the light that passed through a crystal. In this way they could provide correction factors, or an absolute sensitivity performance curve, that can be used for each crystal no matter what energy it is exposed to in the facility.

Sandia's Z machine produces fusion events using the "Z pinch" method, in which a bank of capacitors stores a huge electric charge that is released instantaneously, with about 27 million amperes of current. At the center of the facility's giant drum – about three meters (10 feet) in diameter by six meters (20 feet) tall – is a tiny pellet of heavy hydrogen (deuterium) fuel housed in a container about the size of a spool of thread. The capacitors' intense burst of energy implodes or "pinches" the container evenly, causing the deuterium atoms in the pellet to compress into each other and fuse into heavier elements, a process that releases powerful x rays.

Along with helping to address other basic research questions, this type of crystal will likely be used within the Z machine to resolve a decade-long disagreement over elemental abundances within the Sun.

The Z machine, with its ability to reproduce conditions inside a star on a macroscopic scale, has already played a role in testing these elemental discrepancies. Now, using more sophisticated detectors such as the ones that depend on the new crystals, researchers hope the facility will provide more information for solar scientists on this issue, Loisel says.

--Jennifer Lauren Lee

Source: NIST PML, Radiation Physics Division, Dosimetry Group, September 29, 2015 (http://nist.gov/pml/div682/grp02/nist-calibrates-quartz-crystals-for-fusion-2015.cfm).

Good Metrology Practice (GMetP): Out-of-Tolerance Investigations

Phil Mistretta, CCT
Transcat Inc.

When calibrated test equipment is found with an out-of-tolerance condition, there is additional risk to all products on which it was used. It is important to understand the magnitude of the potential risk because it can lead to dangerous situations and additional business costs. When faced with an As-Found: Out-Of-Tolerance (OOT) condition, a systematic approach to identify what the out-of-tolerance values were, when, where and how the OOT unit was used. This article will provide practical guidance on out-of-tolerance investigations.

Non-Compliance

What does out-of-tolerance mean? Calibration is a comparison to a metrology laboratory standard of known performance and uncertainty, to the unknown behavior of a unit submitted for calibration. When the unit under test (UUT) does not meet the expected test limits, it is considered to be Out-of-Tolerance.

Statement of Compliance

Most commercial calibration customers are looking for the calibration laboratory to make a statement of compliance for the As-Found condition when the equipment comes back from calibration. Sounds simple, but it isn't. There are no perfect instruments and no perfect measurements. All measurements have some degree of uncertainty and how to deal with these uncertainties with respect to making a statement of compliance differs greatly. There are several different approaches which could be used when making compliance statements. For additional information on decision rule see Dr. Steve D. Phillips paper, "Measurement Uncertainty and Traceability Issues: A Standard Activity Update," ASME standard B89.7.3.1 or ISO standard 14253-1. In any case, it is critical for the customer to understand the decision rules used by the laboratory for making compliance statements, or provide the decision rules to the laboratory during the contract review process.

A calibration certificate's statement of compliance may be the single most important piece of information provided to a customer. Industrial manufacturers often have several hundred to several thousand pieces of calibrated equipment managed as an additional responsibility by someone with limited metrology experience. It can be a tremendous benefit to the customer when the calibration laboratory, staffed with measurement experts, has completed this initial data evaluation. Typically, an As-Found: Out-Of-Tolerance (OOT) condition indicates that at least one data point in the data report drifted or shifted beyond the agreed upon calibration test limits and needs further analysis *by the customer*. The OOT statement of compliance is the trigger in the quality system to start an investigation because the OOT instrument's most recent measurements may not have been within performance expectations.

The Investigation Process

The object of the OOT investigation process is to identify if there are any at risk products due to the OOT instrument. This process is designed to eliminate products without risk and to narrow down the pool of at risk products. This is an *investigation*; caution must be observed against having the end result already in mind. It is tempting to show that there were no at risk products. Don't start with a foregone conclusion, the investigation process will lead you to the appropriate conclusion much like the *evidence* a crime scene investigator follows leads to the guilty party. The following approach is nothing more than four questions and some basic math and follows a logical process; however there are a few pitfalls to be avoided.

Range: -10 °C to 160 °C
Accuracy: ± 0.06 °C
OOT: 2 points, 100 °C and 150 °C

Description	Setpoint	Accuracy	Low Limit	High Limit	As Found	OOT	Cal Process Uncertainty (k=2; ±)
Temperature Measure							
Temperature Measure	0.01°C	±(0.06 °C)	-0.05	0.07	0.01 °C		6.0e-004
	50.00°C	±(0.06 °C)	49.94	50.06	49.95 °C		1.2e-003
	100.00°C	±(0.06 °C)	99.94	100.06	100.10 °C	*	1.2e-003
	150.00°C	±(0.06 °C)	149.94	150.06	150.25 °C	*	2.4e-003

Figure 1. As-Found OOT Data

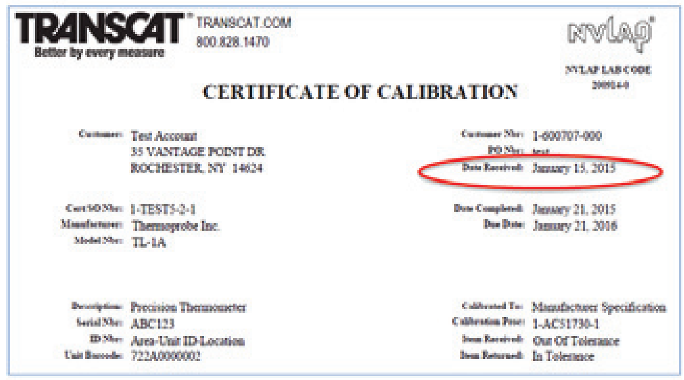
What Was Out-of-Tolerance?

The first thing to do is to read through the calibration data to get a firm understanding of *what* specifically failed calibration. A *complete* set of As-Found and As-Left calibration measurement data is essential for a proper out-of-tolerance evaluation. A Calibration Certificate without data is never a good idea, but when faced with an out-of-tolerance unit, the lack of measurement data will significantly impact the ability to conduct an analysis and quantify any potential risk. Identify what functions, parameters, ranges and test points were found out-of-tolerance. The idea is to answer questions like: how many points within a range were out-of-tolerance; was the entire range out of tolerance; was there a linearity issue; was only the zero out-of-tolerance; or only the full scale reading out of tolerance; were other relevant test points close to or at their limits? The quality of the calibration and quantity of data available can have a tremendous impact on narrowing the scope of the investigation. Figure 1 illustrates an Out-of-Tolerance temperature probe data report.

When Did it Happen?

The next step should be to identify the *time frame* during which questionable measurements may have been taken. This objective is to identify a specific time when the instrument was last known to be taking correct measurements. Often, this will be the As-Left measurement date on the previous certificate. This will provide a starting point to work from, and most likely the longest period to examine. If you are fortunate to have a well-developed measurement assurance program, you might have collected additional data. Such programs conduct mid-cycle checks, tests, and inter-comparisons, also called cross-checks, to determine the "health" of their measurement processes and

Last Known In-Tolerance Date: As-Left Date of Previous Calibration
From: January 5, 2014
To: January 15, 2015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NVLAP LAB CODE

CERTIFICATE OF CALIBRATION

Customer: Test Account
35 VANTAGE POINT DR
ROCHESTER, NY 14624

Customer No: 1-600707-000
PO No: test
Date Received: January 15, 2015

Cert/SO No: 1-TESTS-2-1
Manufacturer: Thermoprobe Inc.
Model No: TL-1A

Date Completed: January 21, 2015
Due Date: January 21, 2016

Description: Precision Thermometer
Serial No: ABC123
ID No: Area-Unit ID-Location
Unit Barcode: 722A0000002

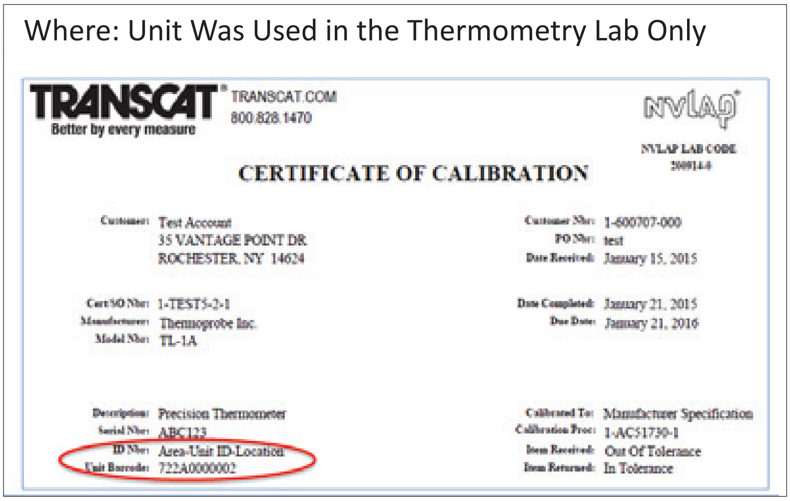
Calibrated To: Manufacturer Specification
Calibration Proc: 1-AC51730-1
Item Received: Out Of Tolerance
Item Returned: In Tolerance

Figure 2. Investigation Time Period

provide confidence in the quality of the measurement process. If these checks are documented and have measurement data, you may be able to reduce the period of questionable measurements. Look for preventative maintenance documentation that might also support a shorter time period. Consider any other testing, process control charts or quality sampling data which could indicate shifts, drifts or bias. Any effort you can make to limit the time frame in question will save you a lot of time later in the Investigation and Analysis Phases. It's much better to only have to look at 6 months of data or 3 months. As with all aspects of an investigation, document everything.

For this example (Figure 2), no documentation was available to support a shorter investigation time period. The investigation time frame was from the last calibration date until the date the calibration laboratory received the unit.

GMetP Tip: Document anytime a unit is removed from service.



Where: Unit Was Used in the Thermometry Lab Only

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NVLAP LAB CODE

CERTIFICATE OF CALIBRATION

Customer:	Test Account 35 VANTAGE POINT DR ROCHESTER, NY 14624	Customer Nbr:	1-600707-000
		PO Nbr:	test
		Date Received:	January 15, 2015
Cert/SO Nbr:	1-TEST5-2-1	Date Completed:	January 21, 2015
Manufacturer:	Thermoprobe Inc.	Due Date:	January 21, 2016
Model Nbr:	TL-1A		
Description:	Precision Thermometer	Calibrated To:	Manufacturer Specification
Serial Nbr:	ABC123	Calibration Proc:	1-AC51730-1
ID Nbr:	Area-Unit ID-Location	Item Received:	Out Of Tolerance
Unit Barcode:	722A0000002	Item Returned:	In Tolerance

Figure 3. Where Used

Where Was It Used?

This is where the really big challenges can start. Identify *where* this instrument has been used during the questionable period. This is where the last link in the chain of traceability is often broken, linking the actual calibrated instrument to the processes, products and services provided. This step entirely depends upon the design of the end users processes and systems. What area, department or production line maintained control of the OOT instrument? Test equipment that moves around without tracking its location is going to be the biggest problem. This is especially true of handheld instruments and bench level instruments. A robustly designed system with strict instrument control procedures will be able to identify exactly where any given instrument was located for any given time frame.

For the example shown (Figure 3), the unit was only available for use in the Thermometry Laboratory.

GMetP Tips:

- Use Area-Id-Location fields on certificates to maintain control.
- Rack mounted equipment tends to stay in place.
- Use visual management techniques such as shadow boards.
- Utilize Tool Cribs and require sign-out and sign-in of equipment.
- Assign equipment to Work Stations or Work Benches.

How Was It Used?

GMetP Tip: Check all revisions of documentation and documents that may have been archived.

The last step in the out-of-tolerance investigation phase is to identify how the out-of-tolerance instrument was being used. We are not determining the impact yet, we are not making a decision here, just collecting evidence. The objective at this step is to determine if the out-of-tolerance instrument *could* have affected any of the products. This information will likely be found in the end users procedures, work instructions, or an engineering specification. This can be accomplished by reviewing the process documentation, and *all revisions* that were in effect during the time frame in question. Were any of the out-of-tolerance functions, parameters, ranges and test points used to make the measurements listed in the process documentation? If the answer is no, congratulations, your evaluation has ruled out the potential risk to product. Now you just have to completely document the steps you have taken, your conclusion and justification; as any auditor or FDA Inspector will tell you, if it isn't written, it didn't happen—you must provide **objective evidence**.

For our example, we identify the unit in question was used in procedures identified in Figure 4.

- This unit is called out by Calibration Procedure CP-0303 R3 and CP-0310 R0
- CP-0303 R3 states this unit is used to monitor a 25 °C Bath
- CP-0303 R3 is dated 1/1/2010
- CP-0310 R0 states this unit is used to monitor a 100 °C Bath

Figure 4. How the Instrument Was Used

We Know:

- What: All reading above 100 °C were OOT
- When: 5 Jan 2014 to 15 Jan 15
- Where: Thermometry Lab only
- How: 100 °C Bath

Magnitude: 0.04 °C

Direction: Thermometer read too high

Description	Setpoints	Accuracy	Low Limit	High Limit	As Found	OOT	Cal Process Uncertainty (k=2; ±)
Temperature Measure							
Temperature Measure	0.01°C	±(0.06 °C)	-0.05	0.07	0.01 °C		6.0e-004
	50.00°C	±(0.06 °C)	49.94	50.06	49.95 °C		1.2e-003
	100.00°C	±(0.06 °C)	99.94	100.06	100.10 °C	*	1.2e-003
	150.00°C	±(0.06 °C)	149.94	150.06	150.25 °C	*	2.4e-003

Figure 5. Investigation Results

A review of the procedures indicate for CP-0303 R3 the unit is used at 25 °C where the unit was intolerance, so there would not be any product impact. However, CP-0310 R0 calls for the unit to be used in an Out-of-Tolerance zone, and therefore may have impacted some product.

Analyzing the Impact

If the answer is yes (as in our example) then the real work begins. You have to quantify the severity of the impacted products or services. In order to effectively complete this analysis, a thorough understanding of the affected process is necessary and a working understanding of tolerances and the application of uncertainties is extremely helpful.

Every bit of measurement information at your disposal allows you to make additional distinctions, observations, calculations and improves the quality and confidence in your conclusions and recommendations for further actions—don't forget to document them!

To determine if the lab standard's OOT condition impacted customer measurements, the magnitude and direction of the unexpected error must be determined. The *unexpected error* is the portion of the As-Found measurement outside of the accuracy limits, either above the upper tolerance limit or below the lower tolerance limit. This is the only amount of error we must take into account when evaluating the reported measurements. Why? Why not the entire error from the nominal? Do not determine the error from the nominal values because the process tolerance should already accounted for expected measurement variation due to the specifications of the unit. Remember, there are no perfect measurements, or perfect instruments, that is why there are process tolerances and accuracy specifications. It is assumed that a suitability analysis was completed and that the unit was acceptable for the intended measurement process, as long as it meets the specifications provided to the calibration lab. Again, the impact analysis should only consider the unexpected error of the unit.

There are two questions to be answered, what is the magnitude and direction of the unexpected error of the unit, and did this unexpected error impact any product. Figure 5 is a summary of the investigation.

Now, our expectation was the thermometer was reading correct. We though the bath was at 100.00 °C ± 0.06 °C , but our UUT was "lying" to us because it was out-of-tolerance. The thermometer was reading 0.04 °C too high, therefore all product readings will also be too high by this same amount. We need to know what the product would have read if the thermometer was reading as expected. To do this we must correct for the thermometers unexpected additional error by subtracting the 0.04 °C error from the product readings, and then recheck the corrected product value against the process tolerances. Did the product still meet process tolerances? If it did, then out-of-tolerance condition of the thermometer did not have any impact on end product. If the corrected product did not meet the process tolerances, then you may have some product that is at risk. At this point it become a business decision as to the next steps, do you recall product or is the additional risk acceptable.

In the example (Figure 6), we thought the bath was reading 100.00 °C, but the bath was actually 100.10 °C. Remember, the bath process tolerance is ± 0.06 °C. While we can live with that bath delivering a temperature between 99.94 °C and 100.06 °C, we cannot live with the bath being 0.04 °C above that temperature. The product was reading 99.90 °C; if the thermometer was reading as expected, the product would have read 0.04 °C lower than was recorded. So applying this correction the product would have read 99.86 °C, then the question becomes, did the product still meet it requirements?

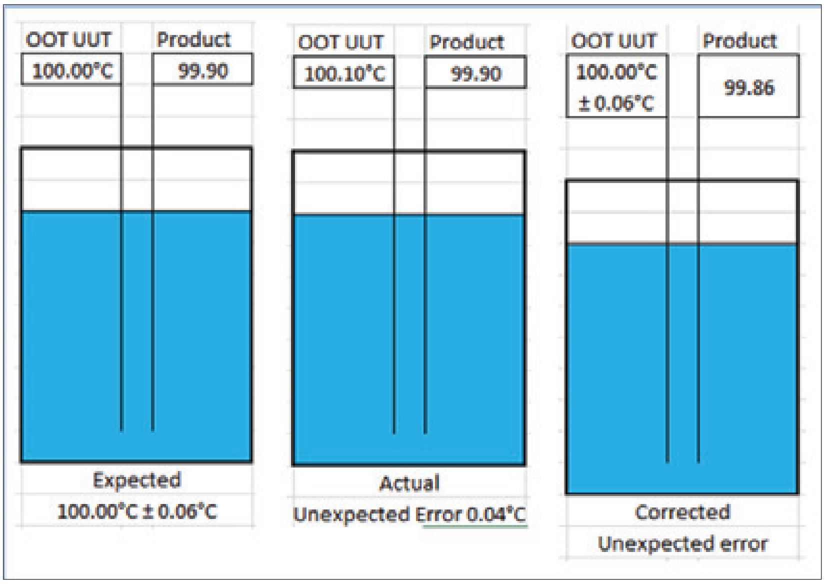

Figure 6. Analysis

Conclusion

The cost of a single product recall will far exceed any cost and time spent in the investigation process. The investigation process objective is to filter out as many possible items that *do not* need detailed analysis. All this evaluation and analysis is a tremendous amount of work. A well-organized electronic system linking instrumentation to processes, and product traceability as part of a measurement assurance program can ease the burden of out-of-tolerance evaluations. A measurement assurance program is more than a calibration program; it is a thought process, a link that relates measurements through the entire produce life cycle, from concept to end product.

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The Metrology of PCB Signal Integrity

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High speed data computations and routing rely on incredibly complex circuit board designs with data transfer rates fast approaching picosecond timing precision (that is one trillionth or one millionth of one millionth of a second). To ensure new products fulfill design expectations, circuit boards must be measured to ascertain data signal quality and confirm circuit simulations. The following article explores some of the most common measurement methodologies used in validating high speed circuit board designs.

Today's high data rate products such as computers, servers, storage devices and routers are required to transfer information in the gigahertz. Most of that data traffic as routed and manipulated within printed circuit boards (PCBs) is accomplished using simple copper traces surrounded by dielectric (isolation) material. As electrons travel data highways within PCBs their speed and amplitude is reduced by the copper trace loss dissipation, the impediment of their E and H fields interacting with surrounding dielectric materials, the influence of other electrons traveling adjacent data highways and of course any power supply disturbances. Physical parameters associated with electrons as they travel in and out of PCBs needs to be measured in order to determine the following;

- Prototype product performance is achieving design performance criteria
- In-house and supplier manufactured products are fulfilling performance requisites
- Design changes are achieving their intended purposes
- The root causes associated with field failures

PCB measurements often include the interconnections between PCBs in order to understand the effects of cables, connectors, etc. and as such are often measured as an ensemble. PCB measurements are generally grouped under the activity of signal integrity or simply SI and include the following core parameters for PCB ensembles [1]:

- Transmission Loss (Incident Signal): Signal loss as it propagates in a forward direction
- Return Loss (Reflections): Signal reflections in reverse direction of incident signal
- Propagation Delay: Time to travel through a medium (dielectric) for a given conductor
- Channel Skew: Timing difference between the arrivals of signals
- Crosstalk (Near End and Far End): Coupling of unwanted signals affecting signal of interest
- Group Delay: Propagation of signal frequency components traveling through a medium
- Phase: Difference between signals with same frequency and referenced to the same point in time
- Complex Impedance: Opposition that a circuit presents to a current when a voltage is applied

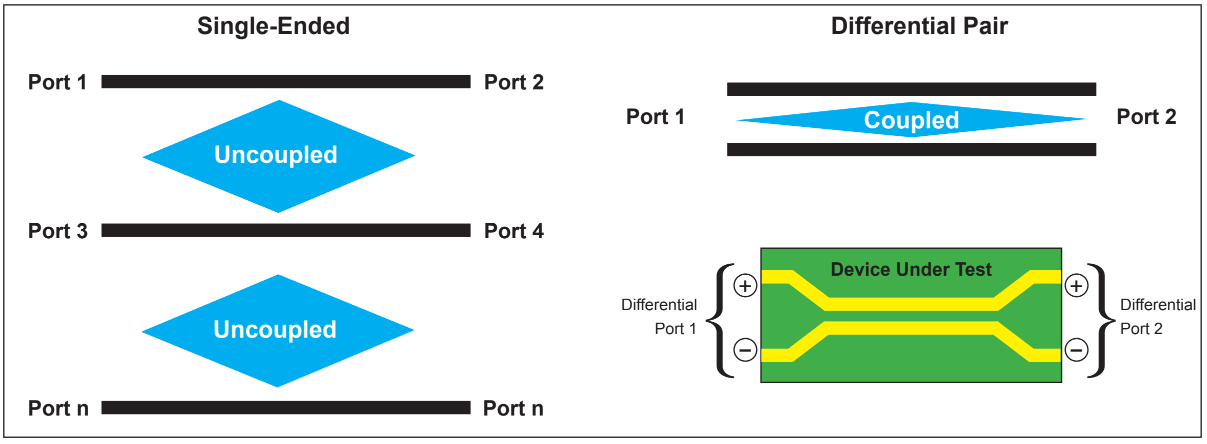


Figure 1.

The aforementioned measurement parameters span both the frequency and time domains with frequency domain parameters classically obtained using a vector network analyzer (VNA) and time domain parameters via time domain reflection (TDR) capabilities incorporated within dedicated test sets or as an option within high frequency oscilloscopes. It must be noted that transformations between frequency and time domain measurements are routinely performed using Fourier or reverse Fourier mathematical algorithms which are normally available within the instrument's controlling software or external data acquisition / analysis software. It must also be noted that many TDR systems have time domain transmission (TDT) capabilities which provide many of the measurement capabilities obtainable via a VNA after frequency domain transformation is performed.

VNA SI Measurements

VNA SI measurements are principally used to measure transmission loss (incident signal) and returned loss (reflected signals), relationships of signals to each other (crosstalk), as well as properties of signals as they pass through a medium (phase, group delay). A typical VNA is comprised of:

- A microwave source for device under test (DUT) stimulus
- Signal-separation devices for unraveling incident from reflected and transmitted signals
- Receivers/detectors for making signal measurements
- Display/processing circuitry for reviewing detector measurement results

VNA are essentially tuned receivers that down convert high frequency signals into the pass band intermediate frequency (IF) of the processing circuitry. Phase is normally determined by measuring signals after they have passed through a medium and comparing it with the phase of a reference signal. Signal separation is performed via directional couplers.

VNAs come in different configurations as determined by the number of their stimuli/measurement ports. Two port VNA are used to measure signals that are single-ended i.e. one signal path. Four port VNAs are used to measure differential signals i.e. two complementary signals paths. VNA's with greater than four ports are primarily used to determine cross talk between multiple signal-ended/ differential signals. Figure 1.0 depicts these configurations;

VNA measurement results are customarily given in terms of s-parameters (scattering parameters). S-parameters are a convenient way to represent signal ratios as experienced by a DUT (see Figures 2 & 3).

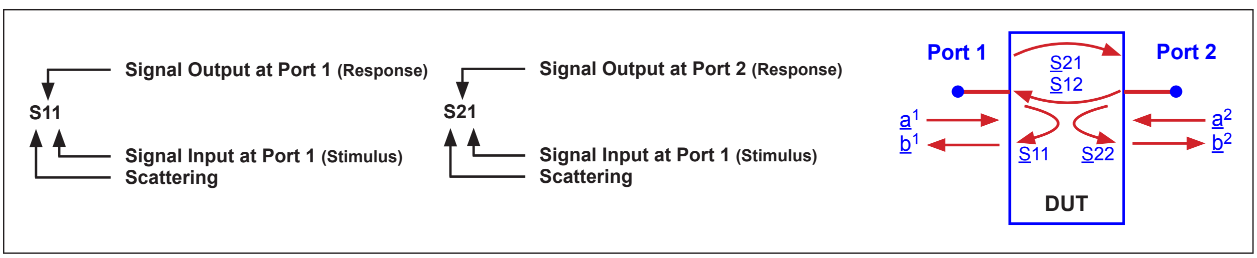


Figure 2.

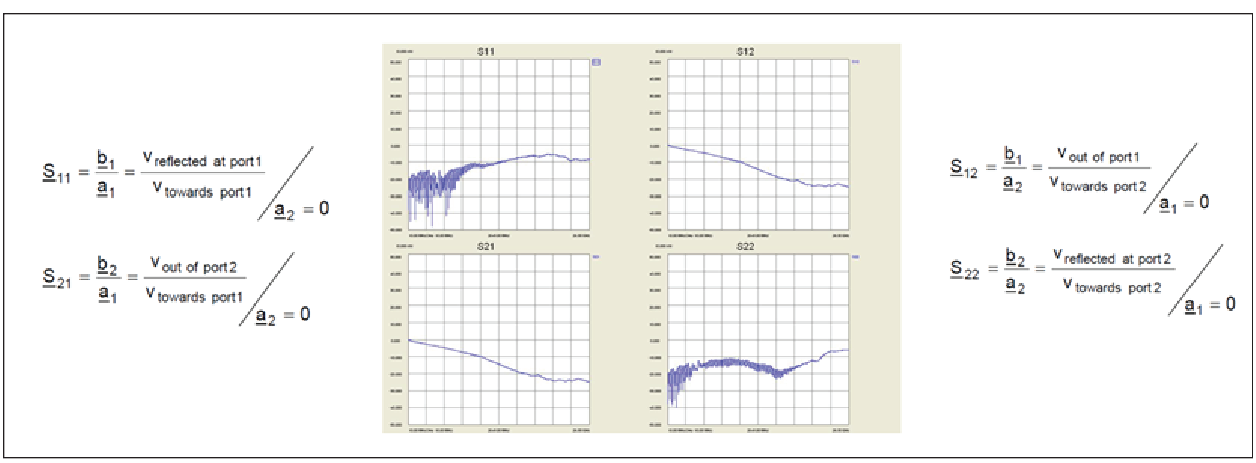
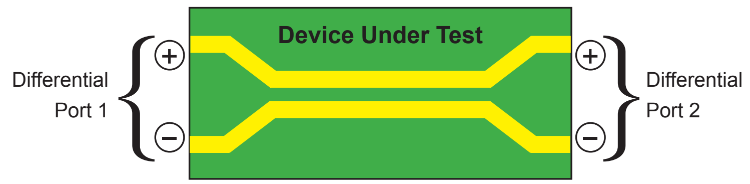


Figure 3.



4-Port Mixed-Mode S-Parameters

Differential Mode to Differential Mode (S_{dd})
Differential Mode to Common Mode (S_{dc})
Common Mode to Differential Mode (S_{cd})
Common Mode to Common Mode (S_{cc})

			Stimulus			
			Differential		**Common Mode**	
			Port 1	**Port 2**	**Port 1**	**Port 2**
Response	**Differential**	**Port 1**	SDD11	SDD12	SDC11	SDC12
		Port 2	SDD21	SDD22	SDC21	SDC22
	Common Mode	**Port 1**	SCD11	SCD12	SCC11	SCC12
		Port 2	SCD21	SCD22	SCC21	SCC22

Figure 4.

Differential s-parameters are depicted in Figure 4 for common mode (signals in phase) and differential mode (signals 180 degrees out of phase).

It must be noted that for differential signals each side of a DUT can have any relative amplitude and phase relationship i.e. different intensities of common and differential modes.

The integrity of s-parameters deals with the following three attributes:

- Passivity: passive channels/devices can only dissipate or temporarily store energy, but never generate it.
- Reciprocity: passive channels/devices normally have the same electrical loss and delay in the forward direction as in the reverse direction.
- Causality: passive channels/devices cannot output a signal before an input signal is applied to it.

S-parameter violations of passivity, reciprocity and causality adversely affect the accuracy of the DUT performance they represent and are often attributable to problems with normalization, calibration, loose connections and/or inadequate ground connections.

VNAs, to provide accurate measurements, should be within their calibration interval and must have been normalized within a relatively short time prior to making any measurements. The calibration of VNAs typically requires periodically measuring (normally annually) known physical artifacts from a VNA performance verification kit comprised of:

- Coaxial attenuators (typically 20 dB and 40 dB)
- Coaxial air-lines (typically 25 ohms and 50 ohms)

VNA normalization is performed using either a coaxial calibration kit or a calibration substrate (micro-probing). These kits/substrates are comprised of known physical artifacts representative of a combination of the following:

- Shorts
- Opens
- Terminations (typically 50ohms)
- Transmission lengths

VNA normalization, often misconstrued as a traditional VNA calibration, mathematically corrects the performance of a VNA in terms of the following, as well as extending the measurement plane from the VNA ports to the end of the VNA cables and/or adapters and/or probes where the calibration kit or calibration substrate artifacts are being connected [2]:

- Reflection Tracking
- Directivity
- Source Match
- Transmission Tracking
- Isolation
- Load Match

It is noteworthy to mention that VNA performance verification kits and VNA calibration kits should be inspected before use for wear and contamination. If applicable, torqued using a calibrated torque wrench and most importantly be within their calibration interval. VNA performance verification kits and VNA calibrated kits that are overdue calibration cannot be assumed to give accurate results.

TDR-TDT SI Measurements

As VNA measurements are performed within the frequency domain, TDR and TDT measurements are performed within the time domain [3]. As previously mentioned time domain measurements can be converted to frequency domain equivalents via Fourier mathematical algorithms. One of the main uses for TDR methodology in SI work is for determining the single-ended and differential complex impedance of PCB ensembles and discrete components. TDR instrumentation, like VNAs, use a normalization routine to reduce measurement errors classically employing a known 50 ohm termination to determine offsets from the TDR instrumentation input impedance (normally 50 ohms) as well as channel to channel skew for differential signals. TDR measurement methodology is essentially analogous to a radar system which sends out an incident signal and detects reflections of that signal when it encounters phenomena which, for TDR signals, is any impedance which differs from system impedance i.e. 50 ohms.

The magnitude of the reflected signal is known as reflection coefficient, commonly referred to as Rho (p). Rho ranges from +1.0 for an open circuit (near infinite impedance) to -1.0 for a short circuit (near zero impedance). A Rho of 0.0 indicates no reflection, i.e. the incident signal is encountering an impedance environment equal to system impedance. Rho coefficient is calculated as follows:

$$p = \frac{\text{Reflection Signal}}{\text{Incident Signal}} = \frac{(ZL - Z0)}{(ZL + Z0)}$$

where, Z0 is system impedance (normally 50 ohms) and ZL is measured reflection impedance.

Measured reflected signal impedance (ZL) can be easily computed via the following:

$$ZL = Z0 * (1 + p) / (1 - p).$$

TDR can be used to determine the distance (length) of reflection relative to the point where the TDR signal is injected. The following formula is used to determine distance:

$$\text{Length (meters)} = (C * V * Td)$$

where
C = Velocity of Light = 2 * 10E8 m/s,
V = Velocity Factor, and
Td = Round Trip Time.

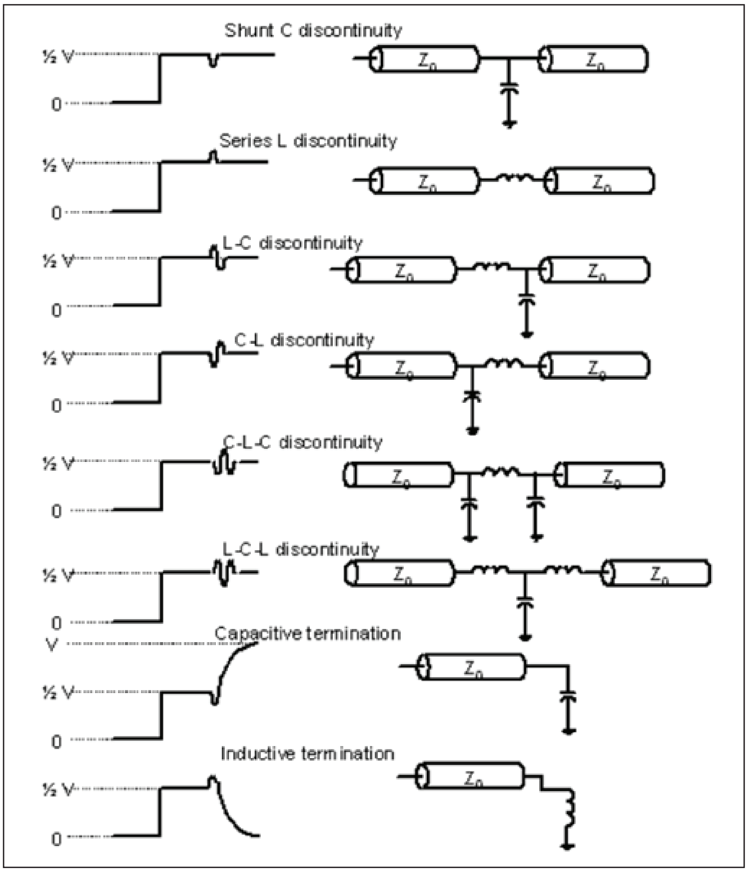


Figure 5. A sample of TDR reflection signals after they have encountered different impedance profiles.

SI Measurement Confidence

As with any measurement worth taking it is both prudent and beneficial to establish confidence in the measurement. First and foremost, measurement equipment should be within their calibration intervals. Prior to performing a measurement, normalization routines should be performed. The use of check standards is highly encouraged in order to quickly determine if the measurement equipment and measurement setup is producing results that one would expect to see. Check standards only need to be stable in order to evaluate measurement repeatability and reproducibility. Check standard measurement results should be archived in order to compare them with previous results which gives insight into the capabilities of the measurement equipment/setup. In the words of President Reagan, 'Trust, but Verify' is a common sense guidance for most measurement applications where measurement data is used to make a decision.

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Methods, Procedures, and Instructions

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A study of noncompliances (deficiencies) during accreditation assessments conducted by Laboratory Accreditation Bureau over several years found that the top most cited clauses were found in section 5.4 - Methods and Method Validation. This paper attempts to clear up some misunderstandings and offer guidance.

I. Introduction

A large number of noncompliances were attributed to section 5.4 (Methods and method validation) of ISO/IEC 17025 based on assessment data collected in calendar year 2012. This is likely due, in part, to confusion caused by the terms "method" and "procedure" used interchangeably in the standard where in practice they are not.

This paper attempts to clarify the intent of section 5.4 in a manner which will enable laboratories to better select, validate, and manage their methods, procedure, and instructions.

This paper will also discuss uncertainty of measurement to clarify what it is and how it relates to test or calibration measurements and the control of test and calibration measurement data.

II. General

Laboratories must have and use appropriate methods and procedures. The conjunction "and" infers that these are two separate nouns having different meanings, however, ISO/IEC17025 uses the words "method" and "procedure" interchangeably which many find confusing. Among these are procedures for sampling, handling, storage, transport, and preparation of items to be tested or calibrated. Where appropriate for the analysis for test/calibration data, methods and procedures are needed for measurement uncertainty and statistical techniques used.

The first definition listed by Merriam-Webster for method is "a systematic procedure, technique, or mode of inquiry employed by or proper to a particular discipline or art" [2] and the first definition for procedure is "a particular way of accomplishing something or of acting" [2]. We see that these two words, in the context of ISO/IEC 17025, have similar meanings and the same basic goal; to accomplish a task in a manner yielding consistent results.

Generally a method is a commonly available published document that describes a measurement or testing technique (e.g. "ASTM E18 - Standard Test Method for Rockwell Hardness of Metallic Materials" or "ASTM E4 - Force Verification of Testing Machines").

Procedures can also be published documents that generally describe a number of steps to complete a task with specific outcomes (e.g. ASTM E18 Annex A - Direct Verification of Rockwell Hardness Machines", or "ASTM E4 - Force Verification of Testing Machines by Elastic Calibration Devices").

Laboratories may or may not find it useful to separate these ideas; however laboratories would benefit from their own understanding and use of the terms "method" and "procedure."

The word "instruction" is used differently; describing documents intended to ensure consistency. Among these are instructions for the operation of equipment, handling and/or preparation of items to be tested or calibrated, and for any activity where the absence of instructions would jeopardize test/calibration results.

Methods, Procedures, and Instructions must be kept up to date (controlled) and available to the personnel they are intended for.

Allowable deviations from these can occur only under certain "documented" circumstances and the subsequent acceptance of the customer.

III. Selection of Methods

Laboratories are required to use methods or procedures which meet customer needs and are appropriate for the test or calibration. This is typically determined during contract review and in order to meet a need, the laboratory must first understand what that need is.

ISO/IEC 17025 states that a laboratory shall preferably use international/regional/national published standards. The word "preferably" makes this an optional "shall."

A laboratory shall ensure use of latest valid edition of standard (method/procedure) unless not appropriate or possible. The word "unless" makes this a conditional requirement based on appropriateness or an impossibility which should be well documented during contract review.

When necessary, a laboratory is required to supplement a method or procedure with additional details to ensure its consistent application. The words "when necessary" make this a conditional requirement. If the method or procedure is sufficiently detailed or laboratory personnel are sufficiently trained making the application of the method/procedure consistent, then supplemental instructions may be unnecessary. The sufficiency or "fitness for purpose" of a method/procedure is determined by the laboratory and is typically confirmed through performance. In life science laboratories, this process is called method validation and is covered in clause 5.4.5 of ISO/IEC 17025. See Section V below.

When a customer does not specify the method/procedure to be used, a laboratory shall select an appropriate method/procedure. Ideally the customer will know exactly what they require, but often they rely on the laboratory to have a subject matter expert. The requirement to understand and meet the customer need remains.

A customer shall be informed as to the method or procedure chosen where the customer has not specified the method/procedure. Again, the laboratory has a responsibility to first inquire as to the customer's need and then, if possible, recommend a method or procedure to meet that need.

A laboratory is required to confirm that it can properly operate a method. Where a published method or procedure is introduced, the laboratory must first confirm they can accomplish the desired tasks. This normally need not be a full validation of the method/procedure, but rather verification that the method can be properly executed.

A laboratory is required to repeat such verification when a method, procedure, or instruction is changed, revised, or updated, or if the published reference method is amended or if major equipment used in the method is changed.

A laboratory must inform the customer if a specified method or procedure is considered inappropriate or out of date even if the customer specifies such an approach. The laboratory must also confirm that it can perform the out of date method/procedure. This confirmation should be well documented as part of the laboratory's contract review.

IV. Laboratory Developed Methods

A laboratory may, for its own use, develop methods or procedures. This must be a planned activity. This is not a typical activity for a commercial laboratory. Normally, this is in support of or in the use of its own equipment design or to support research and development in a new or different technique. This activity must be assigned qualified personnel; typically personnel are assigned specific tasks, equipment, time and other resources.

Normal method development involves changes over time and goals need to adapt to these changes and challenges, as well as any discoveries made. Good communication is instrumental in preventing duplication of activities, sharing discoveries, and surmounting challenges.

V. Non-Standard Methods

When it is necessary to use methods not published as standard methods, this must be subject to agreement with the customer. Where the use of a non-standard method is either because of a customer request or at the laboratory's behest, customer approval of the non-standard method is still required.

There must be a clear, documented specification of customer requirements and purpose of test or calibration, and the method shall have been validated appropriately before use. A clear set of requirements and well-defined purpose, backed by performance data is necessary to determine a method's fitness for use.

VI. Method Validation

This is defined as the confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled. To confirm that the method is fit for intended use, a laboratory shall validate non-standard methods, laboratory developed

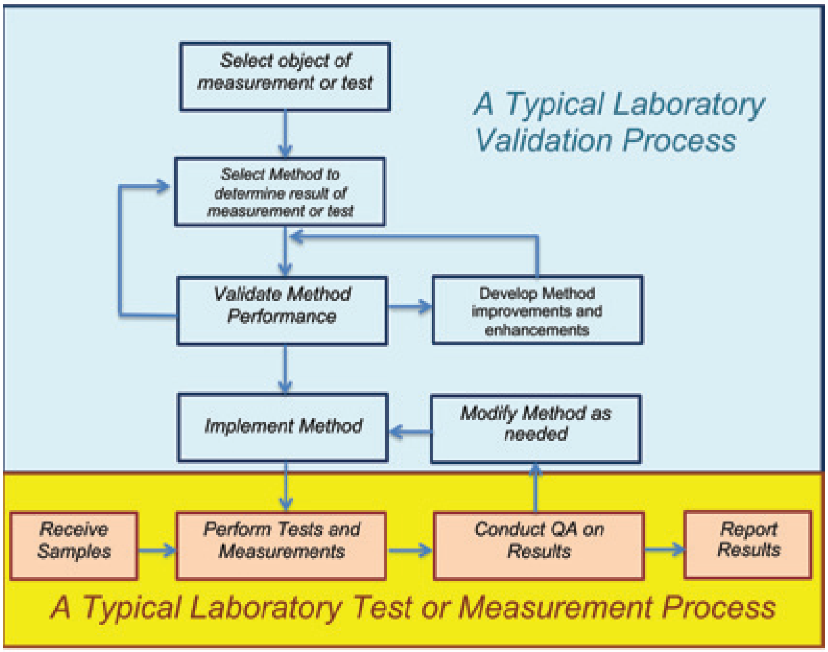

Figure 1. Method Validation in a Laboratory [4].

methods, standard methods used outside their intended scope, and any amplifications (supplements or instructions) or modifications of standard methods.

Method validation techniques vary by scientific discipline and these techniques are dependent upon the scientific discipline in use.

For standard methods, a laboratory shall normally verify its fitness for purpose. This process is normally less involved than full validation, but may involve many of the same considerations.

Method instructions provide the detail necessary to ensure all personnel involved are executing a method or procedure in a consistent manner, specific to the laboratory's equipment, environment, data collection methods, and training programs. These factors may be included in the validation of the method to ensure it is consistent with the method's intent and purpose.

Validation shall be as extensive as necessary to meet the needs of the given application or field of application. The words "as necessary" introduce some necessary ambiguity as ISO/IEC 17025 is a "general requirements" standard; the degree of rigor is determined by the laboratory and is typically confirmed through performance after training. A method similar to an existing one in use may require very little effort to validate, where a newly introduced method may require extensive training, multiple studies, or proficiency tests. A standard method being introduced to a laboratory may require less effort (verification) to determine its fitness for purpose, when compared to a non-standard or laboratory developed method needing full method validation.

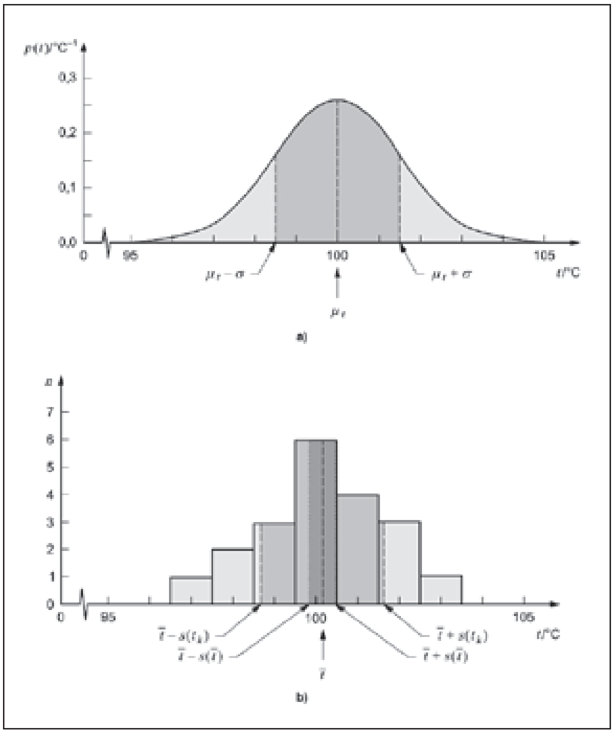

Figure 2. Typical Uncertainty Described in the GUM [3].

A laboratory must document the procedures used and data collected. On completion of the validation work, the laboratory must also formally state whether it believes that the method or procedure is fit for its intended use. The range and accuracy of values obtained from the validated method as assessed for intended use shall be relevant to customer's need. The data and information recorded must also be relevant to the customer's need.

VII. Uncertainty of Measurement

Uncertainty of measurement is one of the parameters that a laboratory can use to determine the fitness for purpose of its tests and calibrations. Uncertainties of measurement are important performance parameters of a method. Testing and calibration laboratories are required to have (and must apply) a procedure for estimating uncertainty of measurement for all calibrations and test measurements.

The simplest description of uncertainty is that it describes the confidence region, around the resultant value, that contains the results taken from a set of replicate measurements. The figure below shows normally distributed results about the reported value.

Where methods preclude rigorous and valid uncertainty estimations, laboratories shall attempt (at least) to identify contributors and make a reasonable estimation and they must ensure that their form of reporting results does not give a wrong impression of uncertainty. Great care must be given as to how uncertainty of measurement is reported

A reasonable estimation of uncertainty must be based on knowledge of the performance of the method. This must be personal or organizational knowledge, as using someone else's knowledge is not adequate. The laboratory is required to also make use of (personal or organizational) previous experience and validation data. Unrelated experience or data is not considered adequate for this effort.

When estimating uncertainty of measurement, all contributors of importance must be taken into account, using appropriate methods of analysis. The laboratory's procedure should determine the level of significance deemed important. Typically it is acceptable to remove from consideration those contributors contributing less than 5% of the standard (k=1) uncertainty. It is customary to include documentation in an uncertainty budget to describe the contributor and justify the omission of its contributing value. It is imperative that the analysis of each contributor is appropriate; considering the PDF (probability density function), its distribution and accompanying divisor, its sensitivity as compared to other contributors, and any correlation to other contributors.

The procedure should instruct technical personnel regarding the minimum content of an uncertainty estimate, commonly called an "uncertainty budget," the typical PDF associated with each identified contributor, and the review and approval processes for these budgets. Many uncertainty procedures describe the PDFs encountered with pictorial representations and identify contributors which typically exhibit these conditions. The laboratory will typically have a number of budgets associated with its scope of accreditation which require the same control as any other document in the quality management system and the frequency or conditions prompting their review. The approval process for uncertainty estimates should include methods to ensure that all significant contributors have been identified, the contributors which are not to be included with the technical justifications for their exclusion, and many laboratories employ a "sanity check" against examples provided in consensus standards or technical reports, similar laboratories' scopes, National Metrology Institute (NMI) capabilities, or the BIPM key comparison database to detect the possibility of an incomplete analysis.

Laboratories often have at least the same quantity of "working" budgets for daily laboratory use which technical personnel can manipulate to match the specific conditions (short-term stability, repeatability, environmental factors) or characteristics (instrument resolution, uncompensated bias) of the item being tested or calibrated. There should be sufficient controls in place to prevent inadvertent underestimation of uncertainty or reporting an uncertainty numerically lower than the laboratory's scope of accreditation.

VIII. Control of Data

Calculations and data transfers must be subject to appropriate checks in a systematic manner. This could be a data transfer from a paper worksheet to computer program used to generate a report, a machine output to paper report, a machine output to computer program, a transfer of data from one computer program to another or a data transfer between computers. Any transfer must be subjected to systematic checks appropriate to the transfer. When computers or automated equipment is used in a laboratory it must ensure that computer software developed is documented and validated. Where a laboratory develops its own or modifies purchased software, that software must be validated fit for use.

Procedures for protection of data must include, but is not limited to the integrity and confidentiality of data entry or collection, data storage, data transmission, and data processing. The laboratory's product is based on this data and it must be protected. The equipment collecting, processing, transmitting, and retaining data must also be protected.

IX. Conclusion

It is imperative that laboratories have a process in place for the selection of methods, procedure, and instructions; however these are understood or defined. These documents must be evaluated (or validated) as being fit for the laboratory's use. Laboratories validating their own methods must have a clear understanding of the particular scientific discipline and their validation processes. Laboratories must also understand their measurement processes well enough to estimate their uncertainties of measurement. Laboratories should be aware that Accreditation Bodies and assessors will typically evaluate uncertainty budgets during their document review by determining if they can model the measurement process based on the information given in the submitted uncertainty budget. Where little information is given or the information lacks sufficient description, more time is planned to review both the procedure and resultant budgets. Laboratories must also have procedures to control their data and any actions taken on that data as it influences other measurements and data reporting.

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Badging for the Metrology Industry

Sita Schwartz
Editor

Online education and interaction precipitates a need for validating individual experiences and qualifications. Electronic badging is becoming more popular as the internet continues to evolve. The platform for electronic badging is open-source, but requires a good amount of resources to implement. In response to this new need for electronic validation, a growing number of companies provide electronic badging services, including Techology, Inc. This Q&A article provides information on the concept of badging and how it benefits those in the metrology industry.

Independent training programs—many of whom have been a continuous part of the measurement science industry for more than a decade or two—have become the mainstay of measurement science education and continuing education for metrology and quality technicians. For these types of programs, there appears to be a two-sided problem: 1) independent trainers have nothing but a paper certificate to give their students after they've successfully completed the training, and 2) students have nothing but a paper certificate to show for it. There is neither a transcript from a college nor a military record showing they successfully completed a metrology/quality program. So how can trainers continue to attract students and how can students display their accomplishments? The answer is badging: an authenticated, digital record of accomplishment for industry within and outside formal institutions alike.

I sat down with Patrick O'Malley, CTO of Techology, Inc. for a Q&A session on badging for the metrology industry.

What are the advantages of badging?

Using digital badges allows an organization to create a portable digital representation of an achievement. This allows the earner to display their badges and achievements on any social media or job-posting site. A digital badge is a certified achievement with tangible evidence that it was earned. This means that if you post a badge on your LinkedIn profile then people looking at your accomplishments will know that the badge was awarded for an actual achievement. The badge can't be faked, so a potential employer will know that it was something verifiable.

Another advantage of digital badges is that they can be combined to form a more complex badge. Badges issued by a university or training company can be broken down into smaller units that show progress towards a larger goal or degree.

So what is a badge?

A badge is a digital representation of an achievement. It is composed of an image representing the achievement and embedded metadata. The metadata is composed of information about the person that earned the badge, links to web sites with criteria for earning the badge, and links to information about the institution that issued the badge.

Badges can be directly accessed from sites that hold badge collections called "backpacks." They can also be awarded as image files, usually in PNG format.

You mentioned the backpack. Can you explain this more?

Sure, a backpack is a web site that performs several functions: It validates that badges are created with the correct structure; it lets badge earners manage their badges, allowing them to make them public or private; and finally, it displays badges for the public and allows the owner of the badge to link to the image from other sites like Facebook or LinkedIn.

What can I do with a badge?

A badge can be shared directly by sending the image to someone or it can be displayed on the earner's website or social media site like Facebook or LinkedIn. It allows someone to showcase his or her accomplishments and knowledge. Badges earned can lead to higher-level badges. A more complex badge can be issued for earning a number of simple badges. You can show your progress towards a complex badge by displaying simpler badges earned.

In some cases, a badge earner may be in a technical trade school or university degree program lasting several years. Using digital badges, they can display the course work they have completed to date. This may allow them to obtain internships or part-time jobs based on experience they have from activities performed to earn badges.

In a non-academic setting, badges can be used to signify participation in an activity such as a 5K run or training program. This opens up a wide variety of badge types that can be awarded.

Who hosts the badge criteria and for how long?

The issuer of a badge has to have a web page that displays the criteria required to earn a badge. They also need a web page that displays information about the issuer and its accreditations. These pages can be hosted by the issuer of the badge or a third party that maintains a service to host digital badges, such as Techology. The creation of a badge is done using a process called "baking" a badge. It combines metadata about the links to the issuer's information, as well as information about the earner of the degree. Once baked, an image file is created that can be downloaded by the earner. This allows the digital badge to be displayed anywhere the earner desires.

Badges have a predefined time period in which they are valid. They are hosted for at least that long. A digital badge can also be downloaded from the issuer, allowing it to be used as long as the earner wishes.

Can a badge expire?

Yes, a badge can expire. Each badge has an expiration date saved within it. The length of time a badge is valid is dependent on the type of achievement and is determined by the issuer. A digital badge for an activity such as a 5K run can have no expiration date since they signify an achievement for an activity. A digital badge issued for taking a certification test that must be renewed every 5 years would have an expiration date 5 years out. The expiration date represents the period of time the badge is relevant, so it is based on the type of activity performed to earn the badge.

What kinds of institutions have implemented badging?

Badging has been implemented by major universities such as Colorado State and by private training companies. It has also been implemented by event sponsoring organizations for activities such as participation in 5K runs or other athletic challenges. Some companies offer one day training activities like cooking classes or craft lessons. These companies have used physical certificates and digital badges to signify a person's completion of a course or lesson. Digital badges have been used by a large variety of organizations to acknowledge accomplishments earned for activities they sponsor.

Resources

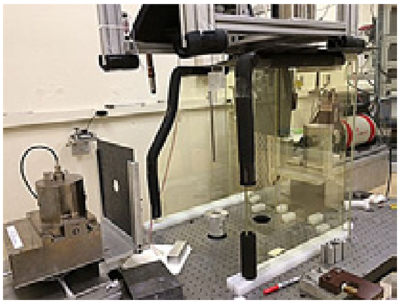
For more information about badging in general, visit:

- http://openbadges.org/
- http://www.badgealliance.org/

It is no coincidence that Techology, Inc. has taken an interest in providing badging for the metrology industry. Cal Lab Solutions, Inc., owner of CAL LAB magazine, is also part owner of Techology, Inc. (http://www.techologyinc.com), a software technology project group.

To find out more about Techology, Inc.'s electronic badging system, visit: http://www.probadging.com.

Examples of a badge graphics, courtesy of openbadges.me. Credit: SPS



Electronic Brachytherapy Laboratory showing Lamperti Free-Air Chamber. Credit: NIST/M. O'Brien

National Air-Kerma Standard for Electronic Brachytherapy

The electronic brachytherapy calibration range incorporates the Lamperti free-air chamber (FAC), a well-ionization chamber, and a high-purity germanium (HPGe) spectrometer to determine the air-kerma of miniature x-ray sources. The 2014 measurement comparison between NIST and a university active in medical physics research resulted in agreement at the 1 % level of the well-ionization chambers. Recent changes to the source measurement geometry resulted in an improved comparison process and a less complicated source alignment procedure. The angular dependency of the source output was incorporated into the value of air kerma for the recent comparison. The new geometry and the ability to directly measure the air attenuation correction was investigated along with the influence of calibration apparatus materials on scattering. Spectra were determined using the HPGe detector with a pinhole collimator. The uncertainty analysis for the recent comparison was updated. Plans to provide traceability to the manufacturer of the sources is underway as well as progress towards the NIST calibration services guide on this project. NIST traceability of clinical source strength measurements will improve both the efficacy and safety of electronic brachytherapy treatments. Establishing the air kerma standard for the current generation of electronic brachytherapy sources will allow baseline dose studies for various medical applications that employ these small x-ray sources. A report describing the air-kerma determination of the electronic brachytherapy sources using the Lamperti chamber is available in the NIST Journal of Research, http://dx.doi.org/10.6028/jres.119.022.

A description of the service and procedures of the measurement of air-kerma and the calibration of well-ionization chambers using the electronic brachytherapy sources is in draft form. The resulting NIST calibration services guide will support the inclusion of this procedure into the NIST 17025 quality assurance document.

Source: NIST PML Dosimetry Group, 08/31/2015, http://www.nist.gov/pml/div682/grp02/e_brachy.cfm.

Free Editor Tool from Cal Lab Solutions, Inc.

IniValueEditor.exe is a specialized editor for allowing safer and more convenient editing of INI files than using Notepad.exe. The editor was originally designed as an external extension tool to assist programs written using the Fluke MET/CAL® development tool set. It can also be used as a standalone program.

This editor was developed as part of an A2LA compliant Fluke 5720 calibrator calibration procedure, developed under contract with U.S. Army Primary Standards Laboratory. In the procedure, an INI file is used to pass correction factors and calibration data required to calibrate the 5720. During the initial delivery and installation of the procedure, it became clear that the usage of the INI file presented some issues and concerns for the average calibration technician. Simply instructing them to edit the calibration data in Notepad.exe was not sufficient. Additionally, we wanted to make sure the users would only edit the calibration data and not unwittingly change the structure of the file, causing issues during the calibration.

The IniValueEditor.exe is designed to only let the users edit the values in the INI file. They are not able to add elements or change the file structure. It can be launched from a Fluke MET/CAL® procedure where the INI file is automatically loaded or from the desktop icon.

Cal Lab Solutions, Inc. is licensing IniValueEditor.exe to the community free of charge. Any user can download the application and run it free of charge as long as they agree to the license agreement.

Company Website Link: http://www.callabsolutions.com/inivalueeditor-a-free-tool-from-cal-lab-solutions/.

Free Software for On-Screen Measurement and Image Capture

Charlotte, NC, Sept. 9, 2015--The Imaging Source, international manufacturer of machine vision cameras and software, has just introduced its new software for on-screen measurement and image capture, IC Measure.

IC Measure is a versatile, high-performance application for the measurement of lengths, surfaces and angles. Its simple user interface also provides image capture and image enhancement functions. The IC Measure calibration tool makes it possible to define image scale (µm – km); the software is quickly calibrated using an ocular micrometer (microscope) or an object of known size (e.g. a ruler).

The measurement tools are designed for macroscopic as well as microscopic applications. The complete integration of image capture and image enhancement makes the manual measurement of lengths, angles, circles and polygons especially efficient. The seamless zoom function allows for pixel-perfect measurement. IC Measure also offers a variety of annotation tools, which allow the user to add texts, graphics and arrow markups. The lens distortion filter efficiently corrects barrel, pincushion, and vignetting distortions. Sophisticated image processing and optimization routines, such as histogram comparison, allow for optimal enhancement of relevant image details.

IC Measure saves single images and image sequences to BMP, TIFF, JPEG and PNG, and video data streams to AVI files. All annotation data can be exported to CSV files. Camera settings, such as exposure time, image refresh rate, focus, noise reduction, contrast, brightness and saturation can be set using IC Measure and saved for future use. For more information >> http://www.theimagingsource.com/en_US/products/software/icmeasure/.

Yokogawa 2560A Precision DC Calibrator

Yokogawa Meters & Instruments Corporation announces that it has developed the 2560A Precision DC Calibrator and will release this product today. The 2560A is a high precision instrument capable of outputting a wide range of DC voltage and current for calibration of analog meters, thermometers, and temperature controllers that use a thermocouple or Resistance Temperature Detector (RTD).

Analog meters, thermometers, and other measuring instruments require periodic calibration to maintain their accuracy. It can be very time-consuming and expensive, however, to send an instrument back to the manufacturer or to other service providers for calibration. In some cases, it is very efficient for some companies to use a high-precision voltage/current standard or calibrator that will allow them to perform this work in house. Since the 1970s, Yokogawa has been a leading provider of measuring instruments with the high level of precision required for use as standards in the calibration of voltage, current, resistance, pressure, and temperature instruments.

In recent years, there has been a rise in demand for DC voltage and current measurement as the result of increased use of direct current in data centers to avoid the power losses caused by AC/DC conversion, and more DC motors have been selected mainly for use as car electric components. With these backgrounds, the demand for DC ammeters that can measure large currents and calibrators for those ammeters are increasing. However, when calibrating the direct current output over 20A, customers may need to combine other instruments that can output 20A or higher using an expensive current amplifier.

2560A is specialized for DC voltage/current generation, and thus, can generate high DC voltage/current output alone with high accuracy and high stability at low cost. In addition to having the same excellent ease-of-use as our previous model, the 2560A delivers substantially improved performance. By leveraging the measurement technologies that it has developed over the years, Yokogawa will strengthen its line-up of calibrators and standard signal generators, and thus, expand its high-precision measuring instrument business.

The 2560A Precision DC Calibrator is an accurate and low-cost calibrator that can output DC voltage over 1200 Volts and DC current over 36 Amps alone. In addition to being able to calibrate analog meters, the 2560A can calibrate thermometers and temperature controllers that utilize a thermocouple or RTD. The key features of this product are as follows:

1. **High accuracy with large DC voltage/current output**. By specializing for DC voltage/current generation, and refining the built-in functions, 2560A kept its price low and achieved the following high performances. It can be used for applications that require high accuracy and stability.
   DC voltage output range: ±1,200V
   DC current output range: -12A to +36A
   Accuracy: ±50 ppm for voltage (180 days in 1V range); ±70 ppm for current (180 days in 1 mA range)
   Stability: ±10 ppm (1 hour in 1V range)
2. **Ease-of-use.** The 2560A is easy to operate, having a dedicated output setting dial for each digit in the numeric display, and a dial for selecting voltage output, current output, temperature calibration, and other functions. Furthermore, it supports various communication interfaces (GPIB, USB, and Ethernet). As its weight is approximately 13 kg, 60% less than the previous model, portability has been improved.
3. **Versatile**. The 2560A can calibrate many different types of thermometers and temperature controllers, and is compatible for use with all 10 thermocouple types, as well as the platinum 100 (pt100) RTD specified by the International Electrotechnical Commission (IEC).

Major Target Markets

-Calibration institutes and calibration maintenance service providers

-Measuring instrument manufacturers

-Electric utilities and power plants

Applications

-Analog meter development, production line testing, and calibration

-Development, production line testing, and maintenance of thermometers, temperature controllers

The SEATIA™ CH-4985 ESD Chair

HUDSON, MA. USA — Global ESD and Cleanroom manufacturer Static Solutions Inc. recently introduced a new state of art ESD chair technology. The USA made chair is made from a molded polyurethane seat, back, and arms unlike the vinyl, or cloth of the competition. The chair has a metal substrate like the competition which increases stability and longevity. The Seatia™ chair has 5 ESD casters unlike a competitive drag chain which often fails due to poor contact, dirt build up and tarnishing. The chair's feature is that the worker is grounded through a wrist strap attached to the chair and is thus connected to earth ground through the chair casters and ESD floor surface. The Seatia™ chair is supplied with a foot ring, side arms and a patented Ohm-Stat™ WS-1020 wriststrap. The chair can be used in a cleanroom environment and has also the ability to be used with employees weighing 350 pounds since it has an extra wide seat.

Features & Benefits:

- Seat dimensions: L: 17.5″ W: 18″ H: 1.75″
- Seat Adjustment: 19″- 26″
- Backrest dimensions: L: 11.5″ W: 16.5″ H: 1.2″
- Overall height (w/adjustment): 33″- 40″
- Arm height: 25.5“
- Width between arms: 16″- 21.5″
- Static dissipative-105-109 ohms RTG
- Product conforms to the ESD S.20.20 spec standards
- 5-ESD casters: no drag chain failures
- Wide seat will support 300 lb.
- Includes Ohm-StatTM WS-1020 patented elastic adjustable wriststrap

For more information, contact Static Solutions Inc. at 978.310.7251, or e-mail contactus@staticsolutions.com.

Calibrate Vibration Sensors in 60 Seconds

Cincinnati, OH - The Modal Shop, Inc., a global calibration authority for 25 years, would like to announce its 9155D Accelerometer Calibration Workstation. The 9155D is a turnkey calibration platform that supports international standards and factory calibration techniques for vibration, shock and dynamic pressure sensors. The system is designed for users who want to ensure control and confidence in a calibration program that conforms to ISO 17025:2005 and 16063-21.

The core of the system is the 9155D software which has a heritage of reliability and stability and delivers a single-axis accelerometer calibration as fast as 60 seconds. The foundation of the vibration capability is the Air Bearing Shaker, which has proven precision and reliability through use in PCB Piezotronics factory accelerometer calibrations and in global calibration laboratories for nearly 15 years.

The K394B30 Air Bearing Shaker utilizes an aluminum and beryllium core to achieve a frequency range of 2 Hz to 15 kHz, while the K394B31 utilizes a beryllium-only core to achieve a frequency range of 2 Hz to 20 kHz. A graphite air bearing combined with an ultra-stiff lightweight armature essentially eliminates transverse motion that plagues traditional flexure-based shaker armature suspension systems.

Model 9155D options include the PneuShock™ exciter for calibration of shock accelerometers to 10,000 g, and the Long Stroke Calibration Shaker with SmartStroke™ technology for calibration of low frequency accelerometers (such as seismic sensors) as low as 0.1 Hz.

Customers choose The Modal Shop, Inc. as a partner in calibration to ensure quality, precision results. Reliability comes from products used in millions of factory-approved sensor calibrations. In addition, The Modal Shop has implemented innovative techniques to provide the highest fidelity of data possible. The company's Total Customer Satisfaction policy supported with tenacious customer service and outstanding tech support is a guarantee.

For more information on our 9155D Accelerometer Calibration Workstation, as well as other available systems, visit our calibration web page at www.modalshop.com/calibration.

Chroma Releases New Compact High Power Programmable DC Loads

FOOTHILL RANCH, Calif. - Chroma Systems Solutions, Inc., a leading provider of power conversion testing equipment and automated systems, announces the release of a new series of high power DC loads designed for testing a wide range of power conversion products including AC/DC and server power supplies, DC/DC converters, EV batteries, automotive charging stations, and other power electronics components. These loads can be synchronously paralleled up to 480kW and dynamically synchronized for generating complex multi-channel transient profiles. The 300% peak overpower capability provides extra headroom for fault condition simulations in automotive batteries, and fuel cells.

Advantages of the 63200A series include ultra-high density power (6kW@4U), built in digital microprocessors, master/slave parallel control, sine wave dynamic loading, and an industry leading measurement accuracy achieving 0.015%+0.015%F.S., 0.04%+0.04%F.S., and 0.1%+0.1%F.S. accuracy for voltage, current and power measurement respectively.

The impressive front panel design includes iconic function selectors via rotary knob or arrow keys and a vacuum fluorescent display. For pain free viewing and access, the entire front panel tilts upward on 7U, 10U and 13U models. Operation can be achieved by the front panel or from a remote workstation via standard USB or optional Ethernet and GPIB interfaces.

The 63200A provides smart Master/Slave mode control which allows the engineer to program the load currents to the Master where they are automatically calculated and downloaded to the slave loads. This control dramatically simplifies operation when using several loads in parallel to emulate a single high power load. All models of the series can be integrated into a standard rack to save space.

Not found in conventional loads, the 63200A offers a dynamic frequency sweep with variable frequencies up to 50kHz. This capability is ideal for determining worst case voltage peaks. Using this function, measurement of the Vpeak (+/-) can be achieved with a sampling rate of 500kHz.

In addition to common CC, CV, CP and CR loading modes of conventional loads, the 63200A accepts digital data from DAQ cards or analog data from function generators to allow for complex waveforms. The 63200A also provides an enhanced feature, User Defined Waveform (UDW), to simulate the actual current profiles and waveforms. To create the actual current waveform, the user can upload captured waveform data into any load via Chroma's softpanel. Each load is capable of storing up to 10 sets of waveforms with each comprising up to 1.5 million data points to meet the more strenuous test requirements. In addition, the 63200A series also provides voltage peak measurement during actual loading conditions, avoiding the need for an oscilloscope to capture the voltage peak.

For solar applications, the built-in Maximum Power Tracking function traces the maximum power point for solar panels. Simply connect the solar panel to the 63200A electronic load, and the built-in algorithm will trace the maximum power point, calculating the total energy consumed.

Battery discharge modes include CC, CR and CP. The electronic load can set cut off voltage and time (1~100,000 sec.) to end loading ensuring the battery is not damaged due to over discharge. In addition, it can measure the battery discharge power (WH, AH) and total discharge time. For example, when Load ON is pressed, the 63200A internal clock will start counting until the battery voltage drops to its cut off voltage or Load OFF is pressed. The battery discharge test also applies to super capacitors for discharge time testing.

For more information on Chroma's 63200A High Power Programmable DC Electronic Loads, logon tohttp://www.chromausa.com or call us at (949) 600-6400.

Renishaw Software Solution for Calibration Systems

Renishaw launched a new free software suite for Renishaw calibration systems at EMO Milano 2015. The suite includes Capture and Explore, which provide data capture and analysis for the XL-80 laser interferometer system. CARTO release 1.1 supports linear, angular and straightness measurement with a choice of keypress, position and remote (TPin) triggering. CARTO features a new database system which automatically stores and organizes data for the user, simplifying operation and allowing users to quickly and easily compare data with historical results.

Capture has been introduced to the CARTO suite as an improved and updated data capture application with the following features:

The orientation of machine movement is detected automatically, reducing the chance for human error in the process.

The intuitive user interface allows new users to begin capturing data quickly with less requirement for training.

All the core functions are available on one screen for efficient navigation.

ISO-10360 target sequences can be automatically created, simplifying a challenging test set-up.

The intuitive CARTO user interface allows new users to begin capturing and analyzing data quickly, without the need for training or reading lengthy manuals. The capacity for customization throughout the suite means that both Capture and Explore can be tailored to suit an individual user's requirements.

Further development on CARTO will follow to add more features, including rotary, flatness and dynamic measurement. CARTO release 1.1 will be available to download free of charge from www.renishaw.com/carto.

For further information on Renishaw's calibration and performance monitoring products, visit www.renishaw.com/calibration.

Teledyne LeCroy High-Bandwidth Coherent Optical Receiver

CHESTNUT RIDGE, N.Y. - Teledyne LeCroy today introduces the IQS series of Coherent Optical Receivers, featuring the industry's highest bandwidth. These products extend Teledyne LeCroy's Optical Modulation Analysis (OMA) portfolio, enabling the creation of flexible, modular systems with unparalleled performance and ease of use. When combined with Teledyne LeCroy's LabMaster 10Zi-A oscilloscopes and integrated Optical-LinQ analysis software, the IQS receivers test DP-QPSK and DP-16QAM optical signals at speeds up to 130 GBaud.

The result of several years of collaboration with the optical specialists at Coherent Solutions, the 70-GHz Teledyne LeCroy IQS70 Coherent Optical Receiver pairs with the LabMaster 10-65Zi-A oscilloscope to provide a system bandwidth of 65 GHz, delivering an ideal solution for characterizing leading-edge 56-Gbaud communications systems and enabling detection up to 130 GBaud. For lower-rate applications, the 42-GHz IQS42 Coherent Optical Receiver provides the ultimate test platform for up to 32-Gbaud DP-16QAM or DP-QPSK when used with the 36-GHz LabMaster 10-36Zi-A.

Completing the world's most comprehensive OMA solution, Optical-LinQ is an intuitive and fully integrated software package for measurement and visualization of optically modulated signals. It runs entirely within the user interface of the LabMaster 10Zi-A. Optical-LinQ provides fully automated control of the IQS receiver, phase recovery algorithms, and polarization demultiplexing, as well as an exhaustive number of modulation analysis displays and parameters.

In addition to a market-leading system bandwidth of 70 GHz, these Optical Modulation Analysis systems provide a dynamic calibration capability to enable the LabMaster 10 Zi-A real-time oscilloscope to be disconnected from the IQS Coherent Optical Receiver and used for other electrical validation and testing without requiring a factory re-calibration. This enables dual use of the oscilloscope for serial-data eye diagrams and jitter, noise and crosstalk analysis on NRZ electrical tributaries using Teledyne LeCroy's SDAIII-CompleteLinQ software package.

For more information, visit Teledyne LeCroy's website at teledynelecroy.com.

(PRNewsFoto/Teledyne LeCroy)

New Additel 209 and 210 Loop Calibrator

Yorba Linda, Calif. - Additel Corporation introduces their new series of loop calibrators designed to troubleshoot the process loop. The Additel Loop Calibrators consist of two models: the ADT209 has an accuracy of 0.03% of reading, and the ADT210 has an accuracy of 0.01% of reading. Each unit simultaneously displays the measured value and percent of span. This series is able to source, simulate or measure the process loop. The ADT209 and ADT210 will measure current, voltage, and a switch. Additionally, they will simulate or source current or a process transmitter. Each unit has an easy to read display and is one-hand operational.

The Additel 209 and 210 Loop Calibrators are now available for order. For more information visit www.additel.com. For information on Additel products and applications, or to find the location of your nearest distributor, contact Additel corporation, 22865 Savi Ranch Parkway, Suite F, Yorba Linda, CA 92887, call 1-714-998-6899, emailsales@additel.com or visit the Additel website at www.additel.com

About Additel

Additel Corporation is one of the leading worldwide providers of process calibration tools. Additel Corporation is dedicated to the design and manufacture of high-quality handheld test tools and portable calibrators for process industries in precision pressure calibration and test instrumentation. With more than 17 years in the industry, Additel has successfully developed Pressure Controllers, Portable Automated Pressure Calibrators, handheld Digital Pressure Calibrators, Documenting Process Calibrators, Multifunction Process Calibrators, Digital Pressure Gauges, and various Calibration and Test Pumps.

Metrology, NOSQL & REST

by Michael Schwartz
Cal Lab Solutions, Inc.

The other day I had a frustrating conversation with a longtime friend and fellow developer related to metrology database design. My company built a system called Metrology.NET™ and designed it to work with any database on the market. The frustration came from my friend's inability to understand objects and states of objects disconnected from a table design in a database. This led me to think about how the world is changing, and how we as automation engineers need to adapt.

One of the new trends in data storage, to include metrology data storage, is the migration from traditional SQL based data access of relational table structures to a more modern NOSQL design. These databases are designed to store massive amounts of data and are more scalable, but the interactions with the data are different. Moving away from the table row model, these databases store relevant data together based on the object model, so we must think of them in terms of the Object Model.

Many of these NOSQL databases store information in name value pairs, where the value can be complex hierarchical information like XML. This new paradigm in database schema is more dynamic, allowing for the storage of dissimilar data in the same location. This facilitates the ability to support data models as they expand over time. If you need more fields or a custom field in your database, just add it to the object and the database figures out how to store it best.

So, this brings us back to the object model. Simply stated, an object model is the collection of properties comprised to define the object, as well as how each object interacts with other objects in the system. For example, we can take a piece of test equipment and represent it as an object. We can define the manufacturer, model number, serial number, asset number, description and options as properties of that item.

```
<equipment>
   <manufacturer>Fluke</manufacturer>
   <model>87</model>
   <serial>012485</serial>
   <asset>AT2314</asset>
   <description>Digital Multimeter
      </description>
   <options> </options>
</equipment>
```

Though this is an over simplification, in a NOSQL database we can store the object in the database and allow the database to figure out the most efficient way to store the data related to the equipment. There is no need to explicitly design a manufacturer table. We can ask the database to give us all unique manufacturers for the equipment; there is no need to design a model table, because we can ask the database to give us all unique instances of a model where manufacturer = Fluke.

The big advantage to all of this is how we transact with the data in our database. Now we can standardize on an object model without regard to how the database stores the data in the database or even what database it is using. A standardized object model also allows seamless migration back and forth between SQL and NOSQL databases. Hence the frustration with my earlier conversation; stop thinking in terms of what fields need to be stored in what tables. It really doesn't matter anymore. Instead think of the problem in terms of object model and properties.

So this brings us to stateless REST transactions with the database. REST stands for REpresentation State Transfer. For this article we are representing a piece of equipment (the Fluke 87) as an object with a set of properties. If I want to save the data in the database, I can send the data to the server using a POST transaction. If I want to read the data from the server, I would use a GET transaction. In each transaction, the operation is stateless, meaning I can save or update the data without any previous calls to the server. I can take the data offline, update it and send it back the following day. And I am not limited to one thing at a time; I can work with several objects all at the same time.

REST transactions are taking the software world by storm. Because it is such a simple and secure means of communication between the client and server, applications are quicker and easier to develop. Its uniform interface of HTTP verbs (GET, PUT, POST, DELETE) has become a standard for network communications.

Over the coming years, you will hear me talk a lot about REST transactions and Object Models. These are extremely powerful tools and concepts allowing us to build better and better metrology systems and services. We can focus on the object model and its data elements and properties, spending less time on database table layouts and building more robust solutions. REST communications allow us a simple and easy way of transacting with our data. Concerns about where and how the data is stored are things of the past. If the company IT decided tomorrow they want to change every database in the company, it has no effect on applications using REST calls. ❧

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