CAL LAB

THE INTERNATIONAL JOURNAL OF METROLOGY

2019
APRIL
MAY
JUNE

Probability of False Acceptance Estimation for Asymmetrical Tolerances

The Importance of Adapters in Force Measurement

Creating Sustainable Metrology Software

Electric Current Measurement

DS Series Current Transducers

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

DANISENSE

- 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

DS2000

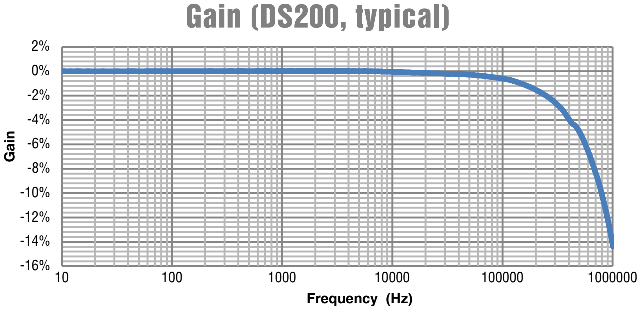
	DS200	DS600	DS2000	DS5000
Primary Current, rms	200A	600A	2000A	5000A
Primary Current, Peak	±300A	±900A	±3000A	±7000A
Turns Ratio	500:1	1500:1	1500:1	2500:1
Output Signal (rms/Peak)	0.4A/±0.6A†	0.4A/±0.6A†	1.33A/±2A†	2A/±3.2A†
Overall Accuracy	0.01%	0.01%	0.01%	
Offset	<20ppm	<10ppm	<10ppm	<5ppm
Linearity	<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

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˚

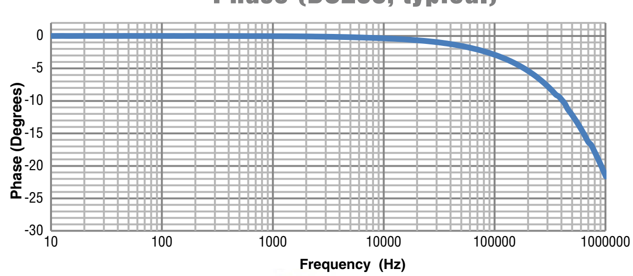
† Voltage Output options available in ±1V and ±10V

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

CAL LAB
THE INTERNATIONAL JOURNAL OF METROLOGY

VOLUME 26, NUMBER 2

www.callabmag.com

FEATURES

DEPARTMENTS

ON THE COVER: Eric Chavier – Lab Manager for Additel – performing ISO 17025 Accredited pressure calibrations at the Additel Corporate Laboratory in Brea, California

CALENDAR

UPCOMING CONFERENCES & MEETINGS

Jul 22-26, 2019 Annual Coordinate Metrology Society Conference (CMSC). Orlando, FL. Established in 1984, the five-day conference is held each year at a different location, and attracts visitors from around the globe. CMSC is acclaimed for its comprehensive program of top-shelf white papers and applications presentations given by industry experts from science/research laboratories and manufacturing industries such as aerospace, space hardware, antenna, automotive, shipbuilding, power generation, and general engineering. https://www.cmsc.org/

Jul 29-30, 2019 ICRM 2019. Istanbul, Turkey. The International Conference on Radionuclide Metrology aims to bring together leading academic scientists, researchers and research scholars to exchange and share their experiences and research results on all aspects of Radionuclide Metrology. https://waset.org/conference/2019/07/Istanbul/ICRM

Aug 8-9, 2019 ICBM 2019. New York, NY. International Conference on Biomedical Metrology aims to bring together leading academic scientists, researchers and research scholars to exchange and share their experiences and research results on all aspects of Biomedical Metrology. https://waset.org/conference/2019/08/new-york/ICBM

Aug 24-29, 2019 NCSL International Workshop & Symposium. Cleveland, OH. Welcome everyone, to the NCSLI 2019 Annual Conference in Cleveland, Ohio. Conference theme: "Metrology in Motion." NCSLI is offering you an exceptional opportunity to attend, present, sponsor and exhibit at the Huntington Convention Center in Cleveland. This state-of-the-art conference venue is one you don't want to miss. http://www.ncsli.org/

Aug 26-29, 2019 IEEE AUTOTESTCON. National Harbor, MD. AUTOTESTCON is the world's premier conference that brings together the military/aerospace automatic test industry and government/military acquirers and users to share new technologies, discuss innovative applications, and exhibit products and services. It is sponsored annually by the Institute of Electrical and Electronic Engineers (IEEE). http://autotestcon.com/

Sep 16-18, 2019 IMEKOFOODS. Brussels (Tervuren), Belgium. Researchers, industries and people involved in food control and nutritional studies, will present and discuss their findings on new measurement techniques, analytical methods & devices, reference materials, measurement uncertainty, data integration & sharing in support to food analyses. https://www.imekofoods4.be/

CAL LAB
THE INTERNATIONAL JOURNAL OF METROLOGY

PUBLISHER
MICHAEL L. SCHWARTZ

EDITOR
SITA P. SCHWARTZ

CAL LAB
PO Box 111113
Aurora, CO 80042
TEL 303-317-6670 • FAX 303-317-5295
office@callabmag.com
www.callabmag.com

Subscription fees for 1 year (4 issues)
$50 for USA, $55 Mexico/Canada,
$65 all other countries.
Visit **www.callabmag.com**
to subscribe.

Printed in the USA.

ISSN No. 1095-4791

EDITOR'S DESK

Internet of Things

Mike and I were in Naples, Italy last month. He was co-presenter of a presentation at the IEEE International Workshop on Metrology for Industry 4.0 and IoT (www.metroind40iot.org). For those hankering lemon or orange granita (hello!) and willing to make the trek, MetroInd4.0&IoT will be in Rome, Italy, June 2020. ✈

The conference focused primarily on Industy 4.0 and how important IoT, "Internet of Things," is for the development of advanced technologies. But I was left scratching my head over how little metrology was directly presented. Indeed, the presentations provided example after example of how precision measurement science has improved and accelerated technologies in R&D, manufacturing, healthcare, automotive, and power industries—to name a few. Maybe it's just hard for me to wrap my head around as I want to approach the concept from the other direction: How can IoT be used to further metrology, particularly in the calibration lab?

Of course, I've seen some presentations from within our small measurement science community that approach the subject from both ends: Blair Hall of New Zealand's Measurement Standards Lab (traceability in digital systems), Roberto Benitez Chavez of Etalons (remote calibration of meters), and Cesar Bautista Jr. (predictive maintenance software using sensors).

How has your work changed over the past 20 years because of the internet—or, how has your work in the field of metrology furthered Industry 4.0 and the IoT? We need more perspectives from within the measurement community. Consider sharing your experience by submitting an article to CAL LAB!

Our feature articles begin with lead RF technician for Micro Precision Calibration, Pedro Adame's "Probability of False Acceptance Estimation for Asymmetrical Tolerances." In it, he presents an equation that can be used to cover a gap in Z540.3 to cover asymmetrical limits.

Henry Zumbrun of Morehouse Instruments contributed a practical and informative article on "The Importance of Adapters in Force Measurement." And finally, our publisher expanded an Automation Corner into a feature article, to address sustainability in metrology software.

Besides our great lineup of articles, this issue also includes: an updated listing of Online & Independent Study programs (page 16) that provide introductory and continued learning for technicians, educational and research press releases, CAL-TOONS by Ted Green, and more!

Happy Measuring,

Sita

Sep 16-18, 2019 Advancing Precision in Additive Manufacturing. Nantes, France. The 6th in the series of joint Special Interest Group meeting between euspen and ASPE on Advancing Precision in Additive Manufacturing is crucial to putting additive manufacturing (AM) onto the factory floor. http://www.euspen.eu/events/sig-meeting-additive-manufacturing-2019/

Sep 16-19, 2019 ASGMT. Houston, TX. The American School of Gas Measurement Technology provides Oil & Gas end-user personnel, manufacturing employees and University students the opportunity to obtain technical training from over 115 lecture classes and 48 hands-on equipment training classes each year. The training is designed to benefit you if you are just beginning your Natural Gas or Liquid career, or if you are a seasoned veteran of the industry. https://asgmt.com/

Sep 24-26, 2019 International Metrology Congress (CIM). Paris, France. CIM2019 is a unique event in Europe proven to be a tremendous hit with the entire profession. A showcase for industrial applications, advances in R&D and opportunities available to industry through expertise in measurements and industrial processes. http://www.cim2019.com/home.html

Sep 24-26, 2019 WESTEC. Long Beach, CA. At WESTEC, you will connect with thousands of leading manufacturers in critical industries such as aerospace, medical, industrial machinery and consumer goods. Our new location, Long Beach, is a gateway to global ports and a vibrant area for machinery. Compare the newest technologies side-by-side while meeting face-to-face with the experts who developed them. Learn more about the business aspects of manufacturing in three days than you typically do in three months at dozens of complimentary educational sessions geared toward industry executives, including interactive Knowledge Bars, topical keynote addresses and informative new-product demonstrations. https://westeconline.com/

Sep 25-27, 2019 SEIA' 2019. Tenerife, Spain. The 5th Annual International Conference on Sensors and Electronic Instrumentation Advancers is a forum for presentation, discussion, and exchange of information and latest research and development results in both theoretical and experimental research in sensors, transducers and their related fields. The SEIA conference is focusing any significant breakthrough and innovation in Sensors, Electronics, Measuring Instrumentation and Transducers Engineering Advances and its applications with broadest concept. The conference is organized by the International Frequency Sensor Association (IFSA), a professional association, which celebrates its 20th anniversary in 2019. http://www.seia-conference.com/

SEMINARS: Dimensional

Aug 5-6, 2019 Gage Calibration and Repair. Los Angeles, CA. IICT Enterprises. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. This course includes "HANDS-ON" calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. https://www.iictenterprisesllc.com/schedule

Aug 8-9, 2019 Gage Calibration and Repair. Las Vegas, NV. IICT Enterprises. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. This course includes "HANDS-ON" calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. https://www.iictenterprisesllc.com/schedule

Aug 13-14, 2019 Dimensional Measurement with Precision Measuring Equipment. Chicago Area, IL. Mitutoyo. This 2-day classroom course is part of our dimensional metrology curriculum and is designed for individuals new to the manufacturing environment who need to use and care for basic precision measuring equipment. https://www.mitutoyo.com/support/mitutoyo-institute-of-metrology/

Aug 15, 2019 Introduction to Dimensional Gage Calibration. Chicago Area, IL. Mitutoyo. This 1-day classroom course is part of our dimensional metrology curriculum and is a blended learning opportunity to maximize the student's time in the classroom. https://www.mitutoyo.com/support/mitutoyo-institute-of-metrology/

Sep 5-6, 2019 Gage Calibration and Repair. Minneapolis, MN. IICT Enterprises. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. This course includes "HANDS-ON" calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. https://www.iictenterprisesllc.com/schedule

Sep 10, 2019 Dimensional Measurement User. Bristol, UK. NPL. A three day training course introducing measurement knowledge focusing upon dimensional techniques. This course is delivered by INSPHERE Ltd, NPL Approved Training Provider. https://www.npl.co.uk/training

Sep 10-11, 2019 Dimensional Measurement with CMMs, Vision and Form Instruments. Chicago Area, IL. Mitutoyo. This 2-day classroom course is designed for anyone using advanced dimensional measuring systems. https://www.mitutoyo.com/online-training/

CALENDAR

Sep 12, 2019 Dimensional Metrology Quality. Chicago Area, IL. Mitutoyo. This 1-day course focuses on measurement quality – including how to understand and assess the errors in dimensional measuring systems. The primary topic of this course is Gage Repeatability and Reproducibility (Gage R&R), a common tool to study variation in measuring systems. https://www.mitutoyo.com/online-training/

Sep 19-20, 2019 Gage Calibration and Repair. Akron, OH. IICT Enterprises. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. This course includes "HANDS-ON" calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. https://www.iictenterprisesllc.com/schedule

Sep 24-27, 2019 Gage Calibration. Chicago Area, IL. Mitutoyo America's Gage Calibration course is a unique, active, educational experience designed specifically for those who plan and perform calibrations of dimensional measuring tools, gages, and instruments. https://www.mitutoyo.com/online-training/

Oct 1-2, 2019 Dimensional Measurement with Precision Measuring Equipment. Mason, OH. Mitutoyo. This 2-day classroom course is part of our dimensional metrology curriculum and is designed for individuals new to the manufacturing environment who need to use and care for basic precision measuring equipment. https://www.mitutoyo.com/online-training/

Oct 3, 2019 Introduction to Dimensional Gage Calibration. Mason, OH. Mitutoyo. This 1-day classroom course is part of our dimensional metrology curriculum and is a blended learning opportunity to maximize the student's time in the classroom. https://www.mitutoyo.com/online-training/

Oct 8, 2019 Dimensional Measurement Applier. Bristol, UK. NPL. A four day training course for those who have a good basic understanding of measurement principles gained through the Dimensional Measurement User training course, delivered by INSPHERE Ltd, NPL Approved Training Provider. https://www.npl.co.uk/training

Oct 8-9, 2019 Gage Calibration and Repair. Indianapolis, IN. IICT Enterprises. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. This course includes "HANDS-ON" calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. https://www.iictenterprisesllc.com/

Oct 10-11, 2019 Gage Calibration and Repair. Chicago, IL. IICT Enterprises. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. This course includes "HANDS-ON" calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. https://www.iictenterprisesllc.com/schedule

Oct 16-18, 2019 Gage Calibration. Chicago Area, IL. Mitutoyo America's Gage Calibration course is a unique, active, educational experience designed specifically for those who plan and perform calibrations of dimensional measuring tools, gages, and instruments. https://www.mitutoyo.com/online-training/

SEMINARS: Electrical

Sep 18-19, 2019 Electrical Measurement. Lindfield, NSW, Australia. NMI. This two-day course (9 am to 5 pm) covers essential knowledge of the theory and practice of electrical measurement using digital multimeters and calibrators; special attention is given to important practical issues such as grounding, interference and thermal effects. https://www.industry.gov.au/client-services/training-and-assessment

Sep 23-26, 2019 MET-301 Advanced Hands-On Metrology. Everett, WA. This course introduces the student to advanced measurement concepts and math used in standards laboratories. The student will learn how to make various types of measurements using different measurement methods. We will also teach techniques for making good high precision measurements using reference standards. https://us.flukecal.com/training

Oct 21-24, 2019 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. We will also teach various techniques used to make good measurements using calibration equipment. The student will be competent to make measurements after passing the final exam. https://us.flukecal.com/training/electrical-calibration-training/met-101-basic-hands-metrology

SEMINARS: Force

Sep 24-25, 2019 Force Fundamentals. York, PA. Morehouse. This two-day workshop will cover applied force calibration techniques with hands on activities and demonstrations using primary and secondary standards. Demonstrations will expose potential errors made in everyday force measurements. http://www.mhforce.com/Training/TrainingCourses

SEMINARS: General

Aug 8, 2019 Calibration and Measurement Fundamentals. Brisbane QLD, Australia. NMI. This one-day fully interactive course (9 am to 5 pm) covers general metrological terms, definitions and explains practical concept applications involved in calibration and measurements. The course is recommended for technical officers and laboratory technicians working in all industry sectors who are involved in making measurements and calibration process. https://www.industry.gov.au/client-services/training-and-assessment

SEMINARS: Industry Standards

Aug 5-6, 2019 ISO/IEC 17025:2017 The New Standard for Laboratory Competence (MS 111). Grayslake, IL. A2LA. This course is a comprehensive review of the philosophies and requirements of this international Standard. The participant will gain an understanding of conformity assessment using the risks and opportunities-based approach. https://www.a2la.org/events

Aug 6-7, 2019 ISO/IEC 17025:2017 The New Standard for Laboratory Competence (MS 111). Denver, CO. A2LA. This course is a comprehensive review of the philosophies and requirements of this international Standard. The participant will gain an understanding of conformity assessment using the risks and opportunities-based approach. https://www.a2la.org/events

CALENDAR

Aug 13-14, 2019 ISO/IEC 17025:2017 The New Standard for Laboratory Competence (MS 111). Frederick, MD. A2LA. This course is a comprehensive review of the philosophies and requirements of this international Standard. The participant will gain an understanding of conformity assessment using the risks and opportunities-based approach. https://www.a2la.org/events

Aug 27, 2019 ISO/IEC 17025:2017 Bridging the Gap from 2005. Grayslake, IL. QC Training. ISO/IEC 17025:2017 Bridging the Gap from 2005 is a one-day course that gives an overview of the changes made to ISO/IEC 17025 in its latest revision. In this course, the participant will become aware of the significant and subtle changes to existing ISO/IEC 17025 laboratory system, as well as the necessary steps to ensure conformity to the new Standard. https://qctraininginc.com/course/iso-iec-170252017-bridging-gap-2005/

Sep 11-12, 2019 ISO/IEC 17025:2017 The New Standard for Laboratory Competence (MS 111). Grand Rapids, MI. A2LA. This course is a comprehensive review of the philosophies and requirements of this international Standard. The participant will gain an understanding of conformity assessment using the risks and opportunities-based approach. https://www.a2la.org/events

Sep 15-16, 2019 ISO/IEC 17025:2017 for Testing and Calibration Labs. Doha, Qatar. IAS. This 2-day Training Course examines structural components of the standard. Quality system and technical requirements are grouped in a manner that makes them clear and understandable. Technical considerations include traceability of measurement and estimations of uncertainty. https://www.iasonline.org/training/testing-cal-labs/

Sep 16-17, 2019 ISO/IEC 17025:2017 for Testing and Calibration Labs. Washington, DC. IAS. This 2-day Training Course examines structural components of the standard. Quality system and technical requirements are grouped in a manner that makes them clear and understandable. Technical considerations include traceability of measurement and estimations of uncertainty. Quality system discussions include easy-to-understand approaches (with sample forms provided) for continual improvement (risk based thinking) and handling of customer feedback. https://www.iasonline.org/training/testing-cal-labs/

Sep 30, 2019 ISO/IEC 17025:2017 Bridging the Gap from 2005. Grayslake, IL. QC Training. ISO/IEC 17025:2017 Bridging the Gap from 2005 is a one-day course that gives an overview of the changes made to ISO/IEC 17025 in its latest revision. In this course, the participant will become aware of the significant and subtle changes to existing ISO/IEC 17025 laboratory system, as well as the necessary steps to ensure conformity to the new Standard. https://qctraininginc.com/course/iso-iec-170252017-bridging-gap-2005/

SEMINARS: Mass

Aug 13, 2019 Balances and Weighing. Auckland, New Zealand. MSL. This course provides training to assist laboratory personnel demonstrate quality assurance in their measurements. https://measurement.govt.nz/training/

Oct 21-Nov 1, 2019 Mass Metrology Seminar. Gaithersburg, MD. NIST. The Mass Metrology Seminar is a 2 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. https://www.nist.gov/news-events/upcoming_events/

SEMINARS: Measurement Uncertainty

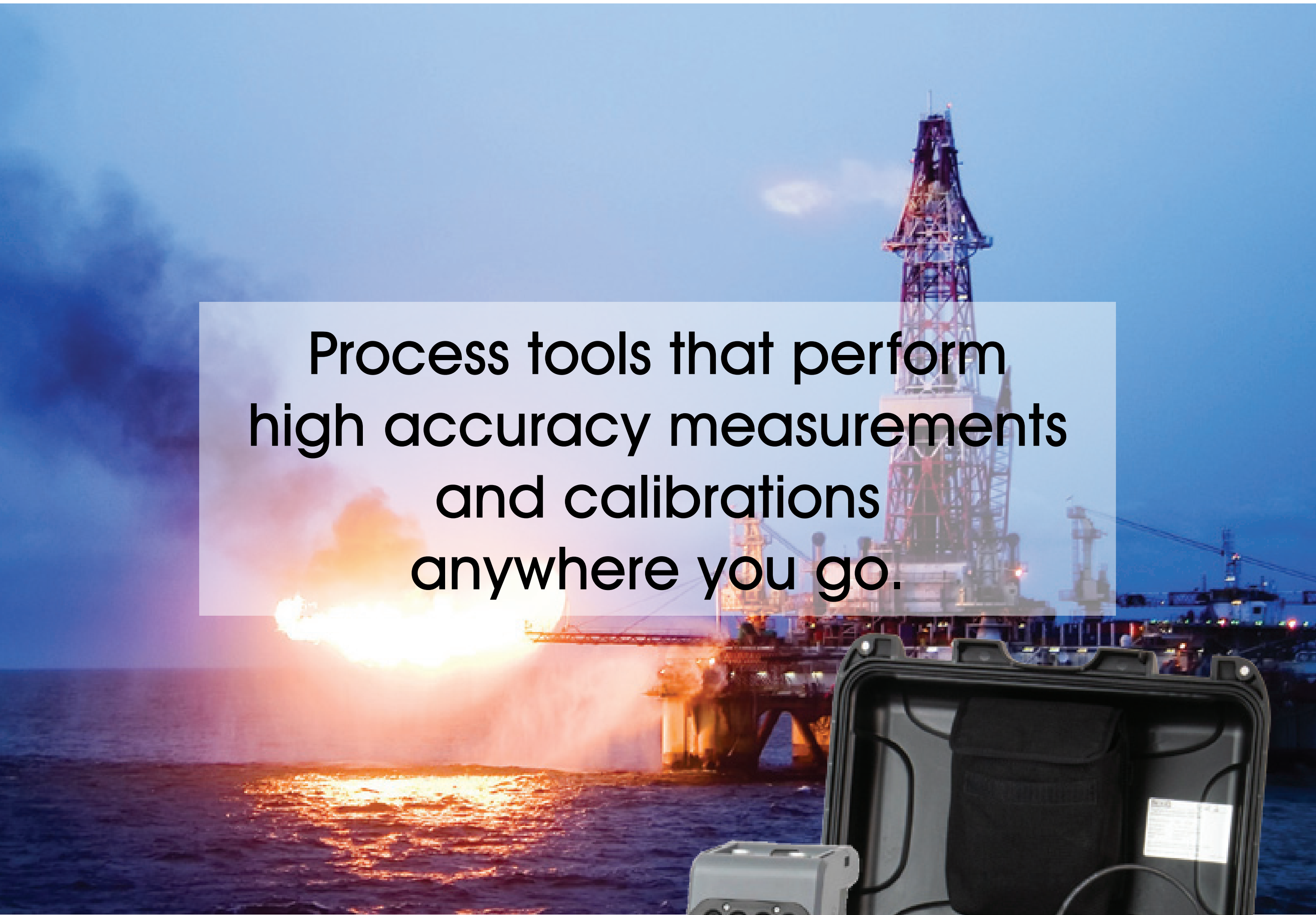
Aug 6-9, 2019 ISO GUM Measurement Uncertainty Analyst Class. Fenton, MI. Quametec. This course is ideal for the training of anyone needing to meet the measurement uncertainty analysis and measurement quality management requirements associated with ISO/IEC17025 and Z540.3. This course is presented in a manner which is suitable for entry level to senior calibration, testing and inspection technicians; metrologists, engineers, and scientists from any discipline. https://www.qimtonline.com/

Aug 7, 2019 Introduction to Estimating Measurement Uncertainty. Brisbane QLD, Australia. NMI. This one-day course will give you a clear step-by-step approach to uncertainty estimation with practical examples; you will learn techniques covering the whole process from identifying the sources of uncertainty in your measurements right through to completing the uncertainty budget. https://www.industry.gov.au/client-services/training-and-assessment

Aug 7, 2019 Introduction to Measurement Uncertainty. Denver, CO. A2LA. This course is a suitable introduction for both calibration and testing laboratory participants, focusing on the concepts and mathematics of the measurement uncertainty evaluation process. https://www.a2la.org/events

Aug 7, 2019 Measurement, Uncertainty and Calibration Workshop. Lower Hutt, New Zealand. MSL. This course gives a broad high-level overview of measurement and calibration principles, and calculation of uncertainty. https://measurement.govt.nz/training/

Aug 14, 2019 Measurement, Uncertainty and Calibration Workshop. Auckland, New Zealand. MSL. This course gives a broad high-level overview of measurement and calibration principles, and calculation of uncertainty. https://measurement.govt.nz/training/



From compact, durable pressure transducers, such as the new CPT6030, to handheld and portable calibrators, Mensor's line of process tools can perform precise measurements and calibrations on-site and in harsh environments.

Options for our industrial instruments:

- Internal pressure & electrical generation
- Intrinsically safe
- Non-corrosive wetted parts
- Loop power
- Portable, waterproof designs
- 4-20 mA transducer output

Talk to an expert about your industry challenges and questions!

www.mensor.com

CALENDAR

Aug 14, 2019 Practical Applications of Uncertainty Training Course. Aberdeen, UK. This course will enable delegates to apply the techniques - developed in NEL's Introduction to Measurement Uncertainty course - to examples tailored to the Oil and Gas sector. Case studies are used to illustrate the application of such calculations in minimizing the impact of measurement uncertainty. https://www.tuv-sud.co.uk/

Aug 20-22, 2019 MET-302 Introduction to Measurement Uncertainty. Everett, WA. Fluke Calibration. This course will teach you how to develop uncertainty budgets and how to understand the necessary calibration processes and techniques to obtain repeatable results. https://us.flukecal.com/training/electrical-calibration-training/met-302-introduction-measurement-uncertainty

Aug 28, 2019 Introduction to Estimating Measurement Uncertainty. Port Melbourne VIC, Australia. NMI. This one-day course (9 am to 5 pm) will give you a clear step-by-step approach to uncertainty estimation with practical examples; you will learn techniques covering the whole process from identifying the sources of uncertainty in your measurements right through to completing the uncertainty budget. https://www.industry.gov.au/client-services/training-and-assessment

Sep 3, 2019 Introduction to Estimating Measurement Uncertainty. Lindfield NSW, Australia. NMI. This one-day course will give you a clear step-by-step approach to uncertainty estimation with practical examples; you will learn techniques covering the whole process from identifying the sources of uncertainty in your measurements to completing the uncertainty budget. https://www.industry.gov.au/client-services/training-and-assessment

Sep 10, 2019 Introduction to Measurement Uncertainty. Frederick, MD. A2LA. This course is a suitable introduction for both calibration and testing laboratory participants, focusing on the concepts and mathematics of the measurement uncertainty evaluation process. https://www.a2la.org/events

Sep 11-12, 2019 Uncertainty of Measurement for Labs. UAE. IAS. The training includes case studies and discussions, with application of statistical components in practical examples that are frequently encountered by testing laboratories. https://www.iasonline.org/training/uncertainty-of-measurement/

Sep 17-18, 2019 Uncertainty of Measurement for Labs. Doha, Qatar. IAS. The training includes case studies and discussions, with application of statistical components in practical examples that are frequently encountered by testing laboratories. https://www.iasonline.org/training/uncertainty-of-measurement/

Sep 23, 2019 Implementing Metrology and SPC Concepts with MS Excel. York, PA. Morehouse. This one-day workshop prepares the metrology professional to apply the power of Microsoft Excel mathematical and statistical tools to assist in managing the laboratory's Quality Management System including Measurement Uncertainty. It serves as a prerequisite for the Measurement Uncertainty workshop and reduces the time spent learning both the Excel and Measurement Uncertainty estimation techniques at the same time. https://www.mhforce.com/Training/TrainingCourses

Sep 26-27, 2019 Advanced Measurement Uncertainty and New ISO 17025 Discussion. York, PA. Morehouse. This workshop covers techniques for laboratories in estimating the measurement uncertainty for their scope of accreditation. This workshop takes the approach of teaching several tools and techniques that a lab may apply in measurement uncertainty analysis estimation per ISO Guide 98 (GUM). https://www.mhforce.com/Training/TrainingCourses

Sep 30, 2019 Introduction to Measurement Uncertainty. Grayslake, IL. A2LA. This course is a suitable introduction for both calibration and testing laboratory participants, focusing on the concepts and mathematics of the measurement uncertainty evaluation process. https://www.a2la.org/events

SEMINARS: Photometry & Radiometry

Aug 5, 2019 Spectrophotometer Calibration Workshop. Lower Hutt, New Zealand. MSL. This course covers the calibration of benchtop spectrophotometers including wavelength accuracy, photometric accuracy and stray light characterization. It is highly interactive and includes hands on sessions to develop practical skills. https://measurement.govt.nz/training/

Sep 24-25, 2019 Photometry and Radiometry Measurement. Lindfield NSW, Australia. NMI. This two-day course (9 am to 5 pm) covers the broad range of equipment and techniques used to measure color and light output, the basic operating principles involved in radiometry, working techniques, potential problems and their solutions. https://www.industry.gov.au/client-services/training-and-assessment

Sep 24-27, 2019 NIST Photometry Short Course. Gaithersburg, MD. Held every two years, this course covers the fundamentals in photometry, radiometry, and colorimetry and practical aspects of measurements of luminous flux, luminous intensity, illuminance, luminance, color temperature, and chromaticity of light sources. https://www.nist.gov/news-events/events/2019/09/nist-photometry-short-course

CALENDAR

SEMINARS: Pressure

Aug 13, 2019 Pressure Calibration Workshop. Auckland, New Zealand. MSL. This workshop is a practical one-day session dealing with all aspects of pressure gauge and transducer calibration. https://measurement.govt.nz/training/

Sep 30-Oct 4, 2019 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).The class is designed to focus on the practical considerations of pressure calibrations. https://us.flukecal.com/training/

SEMINARS: RF & Microwave

Sep 19, 2019 RF & Microwave Measurement Uncertainty. Wellington (Lower Hutt), New Zealand. MSL. This course explores practical scenarios for RF measurements of power and impedance while giving insight into the underlying relationship between measurement uncertainty and error. https://measurement.govt.nz/training/

SEMINARS: Software

Sep 9-13, 2019 Advanced MET/CAL® Procedure Writing. Everett, WA. Fluke Calibration. A five-day procedure writing course for advanced users of MET/CAL calibrations software. https://us.flukecal.com/training/

Sep 9-13, 2019 Metrology.NET® Advanced User Training. Denver, CO. Cal Lab Solutions, Inc. This 5-day training will provide an understanding of Metrology.NET and demonstrate how it can be optimized for your lab, covering: hands-on creation & configuration of a test project, development of device drivers, debugging techniques, creating and using resources in Metrology.NET, and more! http://www.metrology.net/5-day-advanced-user/

Oct 7-11, 2019 MET/TEAM® Asset Management. Everett, WA. Fluke Calibration. This five-day course presents a comprehensive overview of how to use MET/TEAM Test Equipment and Asset Management Software in an Internet browser to develop your asset management system. http://us.flukecal.com/training

Nov 5-7, 2019 VNA Tools Training Course. Bern-Wabern, Switzerland. Federal Institute of Metrology METAS. VNA Tools is free software developed by METAS for measurements with the Vector Network Analyzer (VNA). The software facilitates the tasks of evaluating measurement uncertainty in compliance with the ISO-GUM and vindicating metrological traceability. The three day course provides a practical and hands-on lesson with this superior and versatile software. https://www.metas.ch/metas/en/home/fabe/hochfrequenz/vna-tools.html

SEMINARS: Temperature & Humidity

Aug 8, 2019 Temperature Measurement and Calibration Workshop. Lower Hutt, New Zealand. MSL. This course covers the use, care, and calibration of liquid-in-glass, platinum resistance, thermocouple, and radiation thermometers. https://measurement.govt.nz/training/

Aug 9, 2019 Humidity and Moisture Calibration Workshop. Lower Hutt, New Zealand. MSL. This practical one-day course will introduce you to humidity generation, calibration and measurement, along with the conceptual framework for understanding the various limitations in humidity measurements. https://measurement.govt.nz/training/

Aug 15, 2019 Temperature Measurement and Calibration Workshop. Auckland, New Zealand. MSL. This course covers the use, care, and calibration of liquid-in-glass, platinum resistance, thermocouple, and radiation thermometers. https://measurement.govt.nz/training/

Aug 16, 2019 Humidity and Moisture Calibration Workshop. Auckland, New Zealand. MSL. This practical one-day course will introduce you to humidity generation, calibration and measurement, along with the conceptual framework for understanding the various limitations in humidity measurements. https://measurement.govt.nz/training/

Sep 16-18, 2019 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. This course is for experienced calibration technicians, metrologists, engineers, and technical experts working in primary and secondary-level temperature calibration laboratories. http://us.flukecal.com/training

Sep 19-20, 2019 Infrared Calibration. American Fork, UT. A two-day course with plenty of hands on experience in infrared temperature metrology. This course is for calibration technicians, engineers, metrologists, and technical experts who are beginning or sustaining an infrared temperature calibration program. http://us.flukecal.com/training

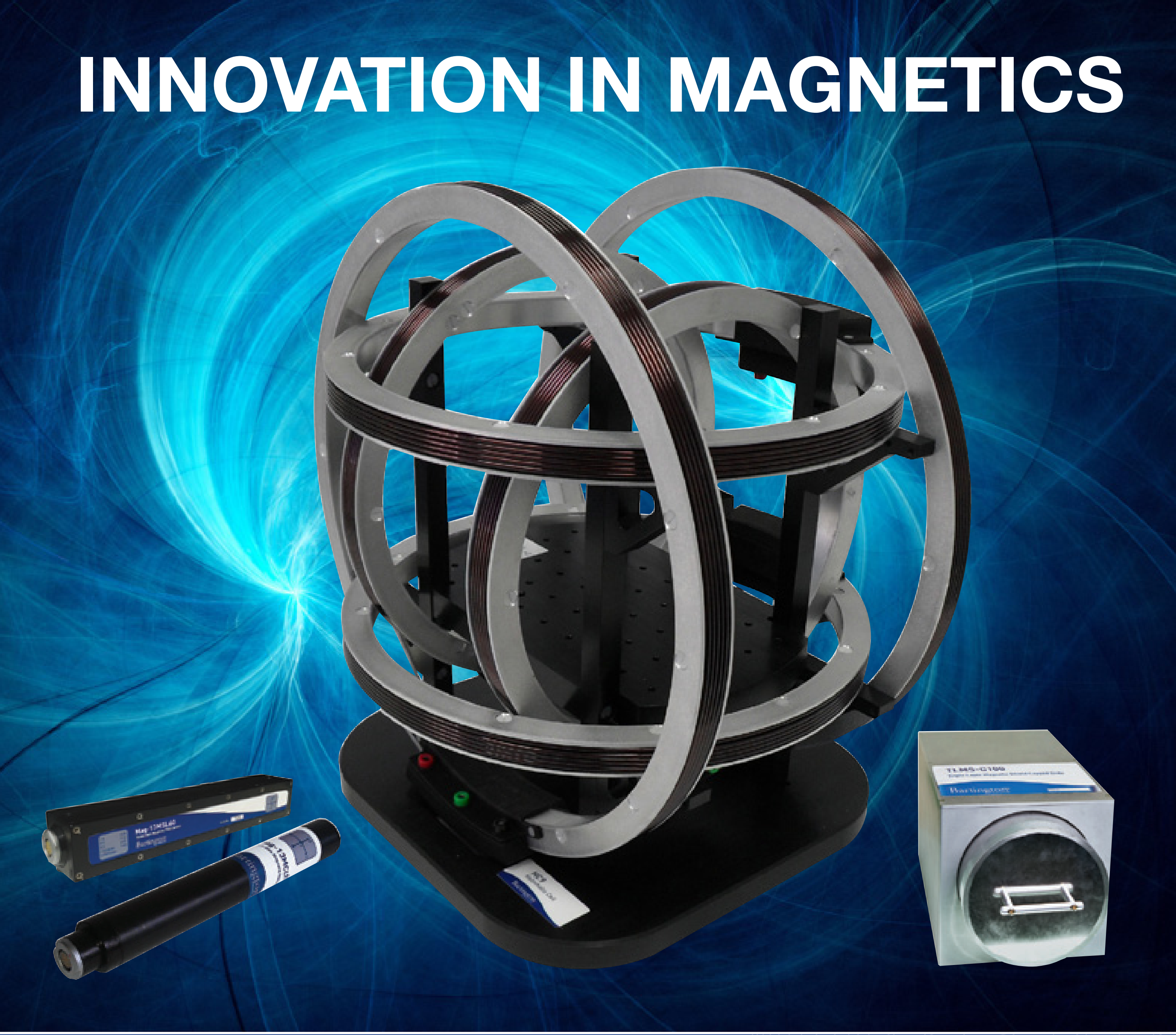
SEMINARS: Time & Frequency

Oct 20-21, 2020 Time and Frequency Measurement. Lindfield NSW, Australia. NMI. This two-day course (9 am to 5 pm) covers the broad range of equipment and techniques used to measure time and frequency and to calibrate time and frequency instruments. https://www.industry.gov.au/client-services/training-and-assessment

SEMINARS: Vibration

Oct 21-23, 2019 Fundamentals of Random Vibration and Shock Testing. Orlando, FL. Equipment Reliability Institute. After this short course, you will be able to measure vibration and shock, calibrate vibration and shock measurement systems, convert field measured data into a test program, interpret vibration and shock test requirements, supervise vibration and shock tests, specify and experimentally evaluate vibration and shock test fixtures, perform ESS, HALT and HASS. https://equipment-reliability.com/

Visit **www.callabmag.com** for more metrology events & webinars!



MAG-13
THREE-AXIS FLUXGATE MAGNETOMETERS

- Noise levels down to <6pTrms/√Hz at 1Hz
- Bandwidth to 3kHz
- Measuring ranges from ±60μT to ±1000μT

HELMHOLTZ COIL SYSTEMS

- 350mm to 2m diameter coils
- Field generated up to 1mT (at DC) and 100μT (at 5kHz)
- Control system including active cancellation

MAGNETIC SHIELDS

- μ Metal 3 and 6 layer versions available.
- Attenuation of Earth's field to ~1nT
- Internal diameters of 100 or 200mm

US distributor:

GMW Associates

www.gmw.com

Bartington™ Instruments

www.bartington.com

Telephone: +1 (650) 802-8292 • **Fax:** +1 (650) 802-8298 • **Email:** sales@gmw.com • **Website:** www.gmw.com

ONLINE & INDEPENDENT STUDY

CERTIFICATIONS

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. https://asq.org/training/catalog

Certified Calibration Technician Prep – Online. QC Training. Students prepare to take the ASQ's Certified Calibration Technician (CCT) exam. This course follows the ASQ body of knowledge with audio/visual presentations of the various topics to prepare the student for the CCT exam. https://qctraininginc.com/course/certified-calibration-technician-prep-online/

DIMENSIONAL

Basic Dimensional Measurement Tools – Self Directed Learning. QC Training. This DVD course forms the basis for mastering more advanced measuring tasks to ensure that you'll get the accurate measurements needed for all data-based improvement efforts. https://qctraininginc.com/course/basic-dimensional-measurement-tools-self-directed-learning/

Coordinate Measuring Machine Basics – Online. QC Training. This course is an entry level course describing the CMM for the individual with limited to no knowledge of CMMs. Course content includes history of the CMM, basic terminology, specifications, standards, accuracy, and measurement uncertainty as applied to CMMs in general. https://qctraininginc.com/course/coordinate-measuring-machine-cmm-basics-online/

Dimensional Measurement User – E-learning. National Physical Laboratory. In this training course, learners will be introduced to dimensional metrology and the importance of good measurement practice and the right measurement behaviors. https://training.npl.co.uk/course/dimensional-measurement-user/

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

ELECTRICAL

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. https://us.flukecal.com/training

Electrical Instrumentation for Applied Measurements – OnDemand Internet Course. Technology Training, Inc. This course provides a basic understanding of electrical measurement systems, as well as the engineering concepts for the whole measurement system. https://ttiedu.com/

Precision Electrical Measurement – Self-Paced Online Training. Fluke Training. Making precision measurements is a skill that takes practice and experience to master. This course will increase your knowledge of terminology, concepts and procedures to help you become more proficient. https://us.flukecal.com/training

GENERAL

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

Calibration Laboratory Operations – OnDemand Internet Course. Technology Training, Inc. This course is for individuals who are involved in standards and calibration laboratories and for others who want a clear understanding of the special requirements that must be met by managers and other personnel in standards and calibration work. https://ttiedu.com/

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

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. https://asq.org/training/catalog

Introduction to Metrology - e-Learning. National Physical Laboratory. This half-day, certified e-learning course has been designed to introduce metrology – the science of measurement – and explore its value for industry, the economy, science and society. https://training.npl.co.uk/course/introduction-to-metrology/

Instrumentation for Test and Measurement – OnDemand 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. https://ttiedu.com/

Measurement and Calibration Overview – Online Training. QC Training. This course is an introduction to the topics of measurement and calibration designed to give the student a general overview of the subject. It may also be considered a metrology 101 course for the new calibration technician or support personnel desiring to learn more about measurements. https://qctraininginc.com/course/introduction-to-measurement-calibration-online/

Measurement Fundamentals Explained – e-Learning. National Physical Laboratory. This is the first online open unit from NPL's 'Measurement Explained' series. This unit introduces metrology, the science of measurement, along with some basic metrology concepts. This is the ideal precursor to our more extensive, certified, Introduction to Metrology e-Learning course. https://training.npl.co.uk/course/measurement-fundamentals-explained/*

Measurements Overview (QIMT1200) – Online Metrology Courses. Quametec. A parallel series of courses, which provide an introduction to, and description of, typical measurements performed in the dimensional, physical and electrical disciplines in science and industry. https://www.qimtonline.com

Metrology Applications for Engineers and Scientists – Web-based. ASQ. This course focuses on the science of measurement. When completed, you'll have a proper understanding of metrology concepts, basic statistics, reliability statistics and measurement uncertainty. https://asq.org/training/metrology-applications-for-engineers-and-scientists-metappwpt

ONLINE & INDEPENDENT STUDY

Metrology Concepts – OnDemand 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. https://ttiedu.com/

INDUSTRY STANDARDS

Assessment to the Requirements of ISO/IEC 17025 – Web-based. ASQ. This course is targeted toward management and what they need to be conformant to the standard. Learn about the requirements of the standard, how to prepare for the audit, how to conduct and audit of calibration suppliers. https://asq.org/training/catalog

ISO/IEC 17025 Compliance – Web-based. ASQ. Understand the terminology, concepts, and procedures relating to ISO compliance and uncertainty management. This self-paced online course is ideal for Calibration Coordinators, Calibration Technicians and Engineers, and Quality Coordinators and seeking to understand of the ISO 17025. https://asq.org/training/catalog

MASS

Basic Mass Computer-Based Training. NIST Weights and Measures Laboratory Metrology Program. Free download available in English and Spanish. https://www.nist.gov/pml/weights-and-measures/laboratory-metrology/lab-metrology-training.

MEASUREMENT UNCERTAINTIES

Introduction to Measurement Uncertainty – e-Learning. National Physical Laboratory. This half day, certified e-learning course explores measurement uncertainty and related concepts. The course consists of a series of multimedia presentations, exercises and an extensive selection of additional content, delivered through a self-paced learning experience. https://training.npl.co.uk/course/introduction-to-measurement-uncertainty/

Measurement Uncertainty – OnDemand Internet Course. Technology Training, Inc. Course 132 begins with an introduction to measurement uncertainty and to the terms associated with it. Then the accuracy and limitations of statistics are discussed, with examples of the various types of distributions encountered in statistical tests. A discussion of sources of errors and their classification into random and systematic follow, before presenting the details of using traditional versus expanded uncertainty equations. https://ttiedu.com/

Measurement Uncertainty – Self-Paced Online Training. Fluke Calibration. Learn the fundamental concepts and how to successfully determine measurement uncertainty and quality improvement techniques. https://us.flukecal.com/training

Measurement Uncertainty – Web-based. ASQ. The focus of making quality measurements is to reduce uncertainty where possible, and to increase confidence in the measurements. It doesn't matter where the measurements are made: knowing about measurement uncertainty is important in expressing measurement results in design, manufacturing, or quality in the aerospace, medical device, automotive industry or a calibration laboratory. https://asq.org/training/catalog

Measurement Uncertainty Analysis – Online Training. The QC Group. This course is an introductory presentation about Measurement Uncertainty concepts and calculations required of most calibration and testing laboratories accredited to ISO standards. https://qctraininginc.com/course/measurement-uncertainty-analysis-online/

Measurement Uncertainty Analysis (QIMT1410) – Online Metrology Course. Quametec. This course takes the student through the basics of the ISO GUM (Guide to the expression of Uncertainty in Measurement) to advanced concepts and methods designed to enable the student to perform measurement uncertainty analyses, from the simple to the complex, with confidence. https://www.qimtonline.com

Measurement Uncertainty Explained – e-Learning. National Physical Laboratory. This free course will introduce the basics of measurement uncertainty. It will provide an introduction to the concept and importance of measurement uncertainty and demonstrate the basics of uncertainty evaluation in eight steps. This is the ideal precursor to our more extensive, certified, Introduction to Uncertainty e-Learning Course. https://training.npl.co.uk/course/measurement-uncertainty-explained/

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

Understanding Uncertainty Budgets – e-Learning. National Physical Laboratory. This course teaches measurement uncertainty through practical examples of uncertainty budgets. https://training.npl.co.uk/course/understanding-uncertainty-budgets/

RF MICROWAVE

Basic Antenna Measurement Program. Learning Measure. This program covers concepts associated with basic antenna measurements. 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/programs.shtml

Keysight RF & Microwave Fundamentals eLearning Program. Build a strong foundation in RF & microwave fundamentals. This includes learning about the most important measurements, critical success factors for ensuring accuracy, and how to get the most productivity and value from your Keysight instrument. https://www.keysight.com/find/rffundamentals

VIBRATION

Vibration and Shock Test Fixture Design – OnDemand Internet Course. Technology Training, Inc. Course 157 starts with a basic introduction to shakers and vibration testing. General considerations in fixture design are discussed next, along with an introduction to instrumentation and sinusoidal vibration testing, as they apply to the fixture design and evaluation process. https://ttiedu.com/

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

New $90K Tool to Bolster BC3's Metrology Program

June 26, 2019, (Butler, PA) — A state-of-the-art $90,000 FARO measurement tool gifted to Butler County Community College (https://www.bc3.edu/) will enhance a distinctive and nationally known metrology program whose graduates have the highest potential starting salaries among the college's occupational associate degree selections in science, technology, engineering and mathematics, a BC3 administrator said.

The FARO Quantum S 2.5-meter, seven-axis articulating arm coordinate measuring machine, donated by the manufacturer to the BC3 Education Foundation for use in the college's metrology program, will "open up opportunities for measurement," said Matt Kovac, BC3's dean of STEM, "that we would not have had before."

Eric S. Stanfield is a 1991 BC3 metrology graduate and mechanical engineer with the National Institute of Standards and Technology, Gaithersburg, Md., a nonregulatory federal agency within the U.S. Department of Commerce that ensures uniformity in weights and measures nationally and abroad.

Stanfield and Daniel Sawyer, leader of NIST's dimensional metrology group, consulted with Dr. Robert Bridges, FARO chief scientist, Exton, Pa., whose company contributed what Kovac said is the "most cutting-edge measurement tool we now have" in a BC3 program whose highly sought new graduates can earn between $35,000 and $60,000.

BC3's graduates in metrology – "the science of precision measurement," said Kevin Ruediger, BC3 associate professor of STEM and metrology program coordinator – have been hired by private industry, governmental contractors and governmental agencies.

"Our top-of-the-line arm"

The addition of the Quantum S, said Ruediger, a 1994 BC3 metrology graduate, gives BC3 students "the ability to measure things in three dimensions at the same time."

"Our top-of-the-line arm," Bridges said of the donation.

The Quantum S allows its operator to choose between a hand-held pea-sized tactile probe to touch an object to create with related computer software a 3-D model – or switch to a laser-line probe to scan items that might deform from contact.

Kevin Ruediger, a Butler County Community College associate professor and coordinator of BC3's metrology program, demonstrates measuring the interior of a geowidget with a tactile probe attached to the program's new state-of-the-art $90,000 FARO Quantum S measurement tool in BC3's metrology lab on June 6, 2019. The Quantum S will allow his students to measure in three dimensions simultaneously. "Students … are going to be blown away by it," he said. "This is just beyond anything else we have."

A fully inflated beach ball whose surface is dotted with dimples of varying sizes and at unequal distances from one another could be scanned and replicated into a 3-D model on a computer using the Quantum S, Ruediger said.

"Because of its connection with the computer, the computer can regenerate any kind of dimension that we want, such as it is this long, it is this deep, its hole is this big, it is located in this area," he said.

"This allows us to measure all sides all at the same time with one setup."

"I have hit the 100K mark"

The Quantum S, Ruediger said, is "by far and away" the most advanced tool in a BC3 metrology lab that prepares students for professions that directly or indirectly utilize metrology skills and require only an associate degree.

Those professions may include aerospace engineering and operations technician, electrical and electronics engineering technician, and industrial engineering technician – among others.

The average salary of an aerospace engineering and operations technician was $67,010 in 2018, according to the U.S. Department of Labor's Bureau of Labor Statistics. For electrical and electronics engineering technicians, $64,330; and for industrial engineering technicians, $55,460.

Each field is expected to experience job growth through 2026, according to the Bureau of Labor Statistics.

"I am making basically $50,000 a year," said Jacob Wirginis, 22, a former Saxonburg resident, 2018 BC3 metrology graduate and instrumentation engineer at Alcami Corp., a contract pharmaceuticals company in Wilmington, N.C.

"I have hit the 100K mark," said Bob Dodds, 34, a former Butler resident, former NASA metrologist and 2006 BC3 graduate who is the metrology and maintenance program manager at Xellia Pharmaceuticals in Bedford, Ohio.

"I would say here, in the lab, you could probably start anywhere from $40,000 to $60,000," said Tina Falling, 49, a former Butler resident who said her salary has nearly doubled in the eight years she has been working at a national laboratory in Albuquerque, N.M., since her graduation from BC3 in 2011.

"I was looking for some type of an associate degree where I figured I could get a position relatively easily with a lucrative salary," said Falling, an engineering support technologist. "In starting a new career, metrology seemed like my best option for what I was interested in."

"BC3 is absolutely rare"

BC3 is among the few community colleges nationwide that offer an associate degree in metrology, according to callabmag.com (https://www.callabmag.com/education-training/), which also lists Central Georgia Technical College, Macon, Ga.; and Monroe County Community College, Monroe, Mich.

BC3 is also the only community college in the United States, Ruediger said, that offers an associate degree in metrology with triad coursework in chemical, electrical and dimensional metrology. "It is the broadest program that I know of today," Stanfield added.

"BC3," said Dr. Theodore Doiron, a physicist with NIST, which employs four BC3 metrology graduates, "is absolutely rare. I think most people in the industry know of it."

While more than 225 students from the United States, Ghana and Kuwait have graduated from the 62-credit program that debuted in fall 1981, "We could put 200 people a year in this program and graduate them and get them jobs," Ruediger said.

"It pretty much has had 100 percent employment rate from the time of inception," said Stanfield, a 2015 BC3 distinguished alumnus and 26-year NIST employee who with Dodds is among members of BC3's metrology program advisory council. "There are more job opportunities than there are metrology graduates." Said Dodds: "The degree in metrology is recession-proof."

The Quantum S will provide the opportunity for BC3 metrology students to have a "great introduction to some high-tech capability," Stanfield said.

Added Bridges: "I doubt that very many colleges around have something like this."

"Students are going to come in and say, 'This technology is unbelievable,'" Ruediger said. "They are going to be blown away by it. This is just beyond anything else we have."

Precise Temperature Measurements with Invisible Light

May 6, 2019, NIST News - Ordinarily, you won't encounter a radiation thermometer until somebody puts one in your ear at the doctor's office or you point one at your forehead when you're feeling feverish. But more sophisticated and highly calibrated research-grade "non-contact" thermometers—which measure the infrared (heat) radiation given off by objects without touching them—are critically important to many endeavors besides health care.

However, even high-end conventional radiation thermometers have produced readings with worryingly large uncertainties. But now researchers at the National Institute of Standards and Technology (NIST) have invented a portable, remarkably stable standards-quality radiation thermometer about 60 centimeters (24 inches) long that is capable of measuring temperatures to a precision of within a few thousandths of a degree Celsius.

NIST has a long history of studying radiation thermometers. The new prototype instrument, which builds on that work, can measure temperatures between -50 C (-58 F) to 150 C (302 F). The corresponding infrared wavelengths are from 8 to 14 micrometers (millionths of a meter), which is a sort of thermodynamic sweet spot.

"All temperatures are equal, but some are more equal than others," said NIST physicist Howard Yoon, who created the thermometer design and directed the project, described in the journal Optics Express. "That 200-degree span covers nearly all naturally occurring temperatures on Earth. If you make a big impact in measuring objects in that range, it really matters."

In addition to clinical medicine, temperatures in that region are of urgent importance in applications where contact is not appropriate or feasible. For example, surgeons need to measure the temperature of organs prior to transplant. Modern farmers need accurate temperatures when handling, storing and processing food. Satellites require non-contact thermometers for measuring temperatures on land and the surface of the sea.

Conventional radiation thermometers often contain little more than a lens for focusing the infrared radiation and a pyroelectric sensor, a device that converts heat energy into an electrical signal. Their measurements can be affected by temperature differences along the thermometer and by temperature outside the instrument.

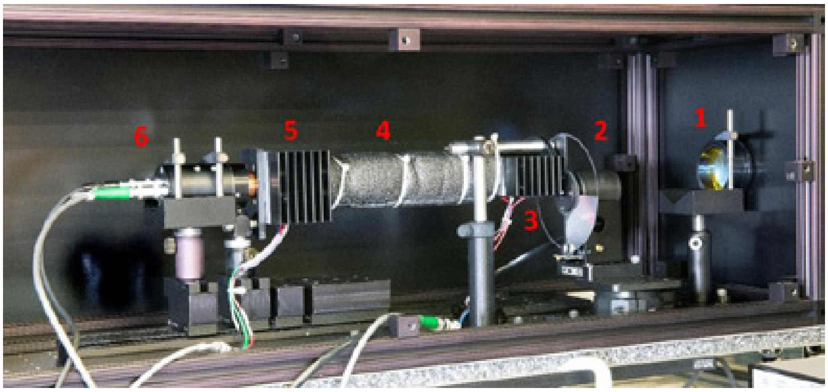
The NIST design, called the Ambient-Radiation Thermometer (ART), is fitted with a suite of interior thermometers that constantly gauge temperatures at different points in the instrument. Those readings are sent to a feedback loop system which keeps the 30-cm (12-inch) cylinder containing the detector assembly at a constant temperature of 23 C (72 F).

It also features other design improvements, including a method for reducing errors from what is called the size-of-source effect, which results when radiation enters the instrument from areas outside its specified field of view.

The ART's major advantage is its unprecedented stability. After it has been calibrated against standards-grade contact thermometers, the instrument can remain stable to within a few thousandths of a degree for months under continuous operation. That makes the system very promising for applications that involve remote sensing over long periods.

"Imagine being able to take the NIST design out in the field as traveling radiation thermometers for accurately measuring variables such as land- and sea-surface temperatures," Yoon said. "It could serve as a trustworthy method of calibrating satellite IR sensors and validating the huge weather science programs that are used to predict, for example, the paths and strengths of hurricanes." Its lower range of -50 C (-58 F) makes it suitable for monitoring the temperature of ice over polar regions, typically in the range of -40 C (-40 F) to -10 C (14 F).

There are several methods of making very high-accuracy temperature measurements, but few are well-suited to field work. Platinum resistance thermometers are fragile and need frequent recalibration. The standard temperature source for transferring that calibration to the ART involves a



Operation of the NIST Ambient Radiation Thermometer, which is approximately 60 cm (24 in.) long: (1) Infrared (IR) light from a fixed-temperature calibrated source (at right, not shown) enters the thermometer enclosure through this lens, which focuses the radiation onto a "field stop," analogous to the f-stop aperture in photography. (2) A circular metal chopper slices the IR beam into a sequence of pulses. (3) The first lens inside the central cylinder converts the light from the field stop to a parallel beam. (4) The light passes through this insulated cylinder about 30 cm (12 in.) long, which is temperature-controlled by a feedback system. Stray radiation is blocked by another stop. (5) A second lens focuses the light onto a pyroelectric detector. (6) The detector output is routed to an amplifier that boosts the signal to readily readable levels. Credit: NIST

heat-source cavity inside about 42 liters (11 gallons) of liquid.

"Those are the best sources we have," Yoon said. "But it is impractical to measure water temperature by putting a thermometer in the ocean at intervals, and you don't want to constantly calibrate your radiation thermometer using a calibration source like that on board a ship."

Gerald Fraser, chief of NIST's Sensor Science Division, said that "Yoon's innovation makes non-contact thermometry competitive with the best commercial contact thermometers in accuracy and stability in a temperature range that humans experience daily. This enables many new opportunities in product inspection and quality control and in defense and security where conventional contact methods are impractical or too expensive."

Paper: H.W. Yoon, V. Khromchenko and G.P. Eppeldauer, "Improvements in the design of thermal-infrared radiation thermometers and sensors." *Optics Express*. Published in May 13, 2019 issue. DOI: https://doi.org/10.1364/OE.27.014246

Source URL: *https://www.nist.gov/news-events/news/2019/05/precise-temperature-measurements-invisible-light*

Redefining the Limits of Measurement Accuracy

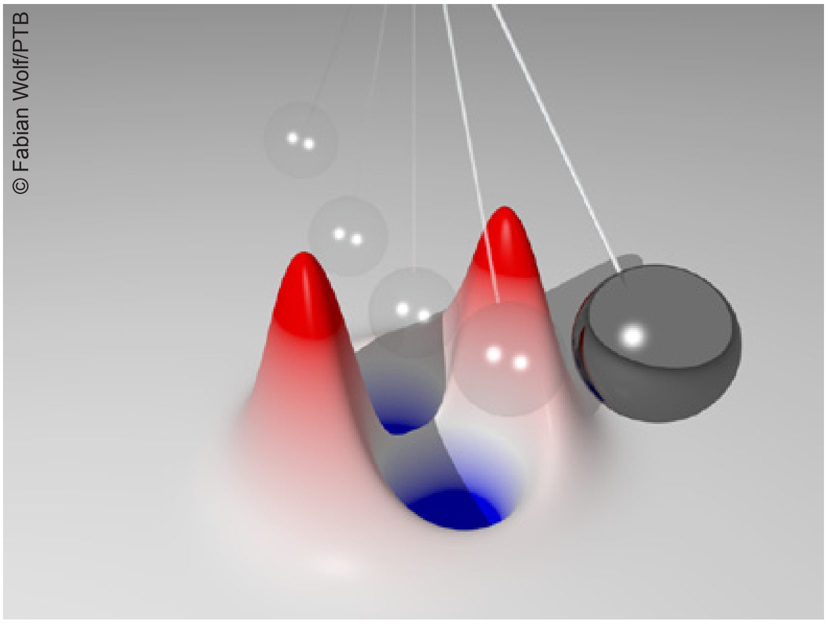
Scientists at the QUEST Institute at Leibniz University, Hannover, and the PTB, have, together with colleagues at the institute of Theoretical Physics at the Leibniz University, Hannover, and with colleagues of the National Institute of Optics in Florence, Italy, introduced a method based on a non-classical state adapted to two measurement parameters at once. This will enable precision measurements of molecules which could reveal interactions between conventional and dark matter. They report on their results in the current issue of Nature Communications.

July 2, 2019, PTB - For centuries, humans have been expanding their understanding of the world through more and more precise measurement of light and matter. Today, quantum sensors achieve extremely accurate results. An example of this is the development of atomic clocks, which are expected to neither gain nor lose more than a second in thirty billion years. Gravitational waves were detected via quantum sensors as well, in this case by using optical interferometers.

Quantum sensors can reach sensitivities that are impossible according to the laws of conventional physics that govern everyday life. Those levels of sensitivity can only be reached if one enters the world of quantum mechanics with its fascinating properties - such as the phenomenon of superposition, where objects can be in two places at once and where an atom can have two different energy levels at the same time.

Both generating and controlling such non-classical states is extremely complex. Due to the high level of sensitivity required, these measurements are prone to external interference. Furthermore, non-classical states must be adapted to a specific measurement parameter. "Unfortunately, this often results in increased inaccuracy regarding other relevant measurement parameters," says Fabian Wolf, describing the challenge. This concept is closely linked to Heisenberg's uncertainty principle. Wolf is part of a team of researchers from Leibniz University Hannover, Physikalisch-Technische Bundesanstalt in Braunschweig, and the National Institute of Optics in Florence. The team introduced a method based on a non-classical state adapted to two measurement parameters at once.

The experiment can be visualized as the quantum mechanical version of a simple pendulum. In this case, the adapted measurement parameters are the pendulum's maximum displacement (amplitude) and the number of oscillations per second (frequency). The pendulum comprises a single magnesium ion embedded into an "ion trap." Via laser light interactions, researchers were able to cool the magnesium ion to the ground state of a quantum mechanical system, the coldest achievable state. From there, they generated a "Fock state" of the motion and oscillated the single atom pendulum using an external force. This allowed them to measure amplitude and frequency with a sensitivity unmatched by a conventional pendulum. In contrast



© Fabian Wolf/PTB

to previous experiments, this was the case for both measurement parameters without having to adjust the non-classical state.

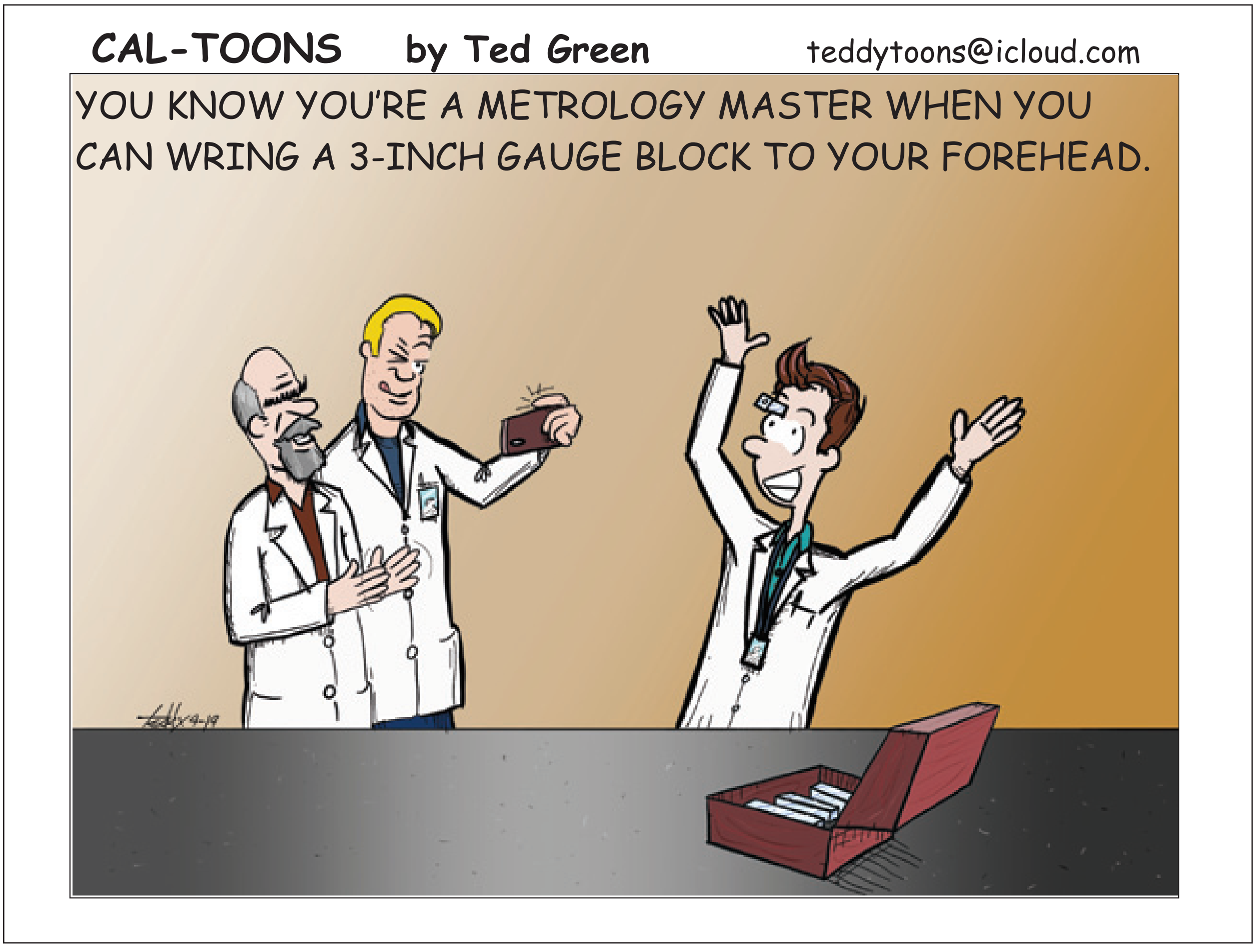
Using this new approach, the team reduced the measurement time by half while the resolution remained constant or doubled the resolution with a constant measurement time. High resolution is particularly important for spectroscopy techniques based on changing the state of motion. In this particular case, researchers intend to analyze individual molecular ions via laser irradiation in order to stimulate molecular movement. The new procedure will enable them to analyze the state of the molecule before it is disrupted by too intense laser irradiation. "For example, precision measurements of molecules could reveal interactions between conventional and dark matter, which would be a great contribution to solving one of the biggest mysteries in contemporary physics," says Fabian Wolf. The measurement concept, which researchers demonstrated for the first time, could also improve the resolution in optical interferometers such as gravitational wave detectors - therefore providing more in-depth insights into the dawn of the universe.

The study originated from the collaborative research center "DQ-mat - Designed Quantum States of Matter," which is in receipt of funding from the German Research Foundation (DFG). The team of researchers has now published their findings in the scientific journal Nature Communications.

Original article: "Motional Fock states for quantum-enhanced amplitude and phase measurements with trapped ions," Fabian Wolf, Chunyan Shi, Jan C. Heip, Manuel Gessner, Luca Pezzè, Augusto Smerzi, Marius Schulte, Klemens Hammerer, and Piet O. Schmidt, *Nature Communications* **10**, DOI: https://doi.org/10.1038/s41467-019-10576-4

Source URL: *https://www.ptb.de/cms/en/presseaktuelles/journalisten/news-press-releases/*

Visit **www.callabmag.com** for more metrology related news!



Probability of False Acceptance Estimation for Asymmetrical Tolerances

Pedro Adame
Micro Precision Calibration

I. Introduction

One of the newest, hence less studied standards for calibration is the ANSI/NCSL International Z540.3 standard. The main difference with the more known ISO/IEC 17025 standard is the need to estimate and include a Probability of False Acceptance (PFA) in the calibration report. According to the Z540.3 standard, this probability has to be below 2% for the measurement to be in compliance with the standard, and even though it is not a requirement in the ISO 17025:2017 standard, the probability of false acceptance can be used as a statement of conformity according to Clause 7.

Since this probability is somewhat hard to estimate, or even understand, ANSI/NCSL provide an Application Handbook [1], where in its Appendix A specifies several methods to comply with the standard.

The easiest and therefore most used methods for complying with the standard are methods 5 and 6 where the calibration uncertainty is applied (either directly or with some modification) as a guard band by subtracting it from the calibration tolerances to create new acceptance limits. The disadvantage with these two methods is that the PFA is not actually calculated (or estimated) but it is only assumed that the measurement is in compliance if the calibration error falls inside the guard banded acceptance limits.

The first four methods provide an actual way to actually estimate the PFA value, but upon analyzing each one of the methods something was noticed: All methods suppose that the tolerance limits and/or acceptance limits are symmetric (the tolerance is the same for both the upper limit and lower limit)(Fig. 1). If this condition is not met, the handbook does not provide any solutions.

II. Developing a PFA Estimation Equation for Asymmetric Limits

The equation presented here provides a way to actually estimate the PFA value and it can be applied in all cases, either with symmetric or asymmetric tolerances/limits. In order to obtain this equation, we must refer back to the Z540.3 standard definition of PFA:

> The probability of making an acceptance decision when the Unit Under Test(UUT) is observed and reported to be in tolerance but is actually out of tolerance. [1]

This definition can be represented as follows:

$$PFA = \Pr([Acceptance]\ AND\ [True\ Out\ of\ Tolerance])$$

Mathematically the PFA can be expressed as:

$$\text{PFA} = \Pr([A_{lo} \le d \le A_{up}]\ AND\ [(e_{bias} < L_{lo})\ OR\ (e_{bias} > L_{up})])$$

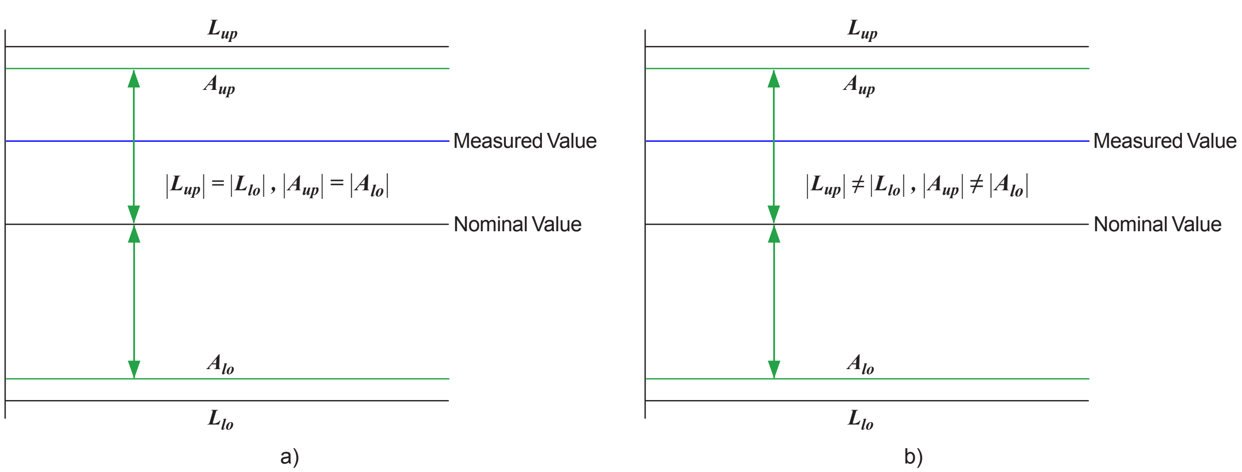


Figure 1. Graphical examples of symmetrical and asymmetrical limits: a) Symmetrical limits and b) Asymmetrical limits.

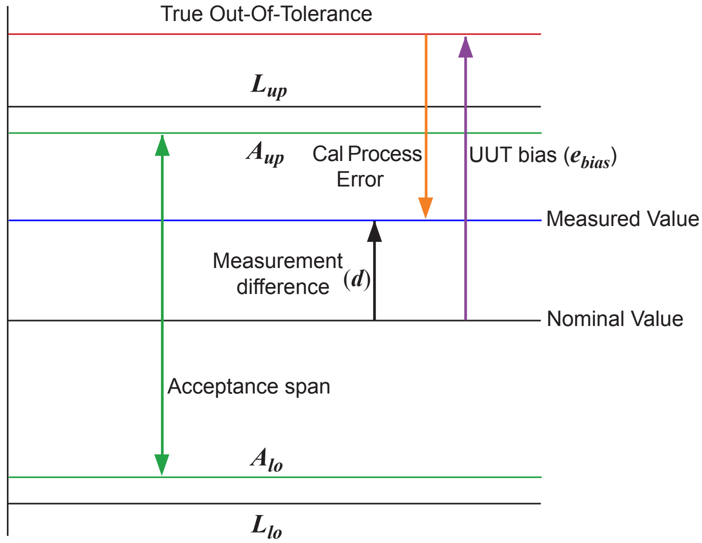


Figure 2. Graphical representation of the false acceptance condition.

where
d is the difference (error) between the UUT and the CalStd (Measured);
e_{bias} is the bias of the UUT measurement (True value);
L_{lo}, L_{up} are the lower and upper tolerance limits, respectively; and
A_{lo}, A_{up} are the lower and upper acceptance limits, respectively.

The false acceptance condition can be represented graphically as shown above in Figure 2.

Since this probability is a function of two variables, a joint probability density function (PDF) can be expressed as $f(d, e_{bias})$. If the error distributions are assumed to be normal (Gaussian), this joint PDF is given by:

$$f(d,e_{bias}) = \frac{1}{2\pi u_d\, u_{bias}\sqrt{1-\rho^2}} e^{\left(-\frac{\left(\frac{d}{u_d}\right)^2 - 2\rho\left(\frac{d}{u_d}\right)\left(\frac{e_{bias}}{u_{bias}}\right) + \left(\frac{e_{bias}}{u_{bias}}\right)^2}{2(1-\rho^2)}\right)}$$

where
$u_d = \sqrt{u_{bias}^2 + u_{proc}^2}$ is the standard uncertainty of the calibration difference,
u_{bias} is the standard uncertainty for the UUT bias,
u_{proc} is the standard uncertainty for the calibration process,
ρ is the correlation factor between e_{bias} and d and is given by:

$$\rho = \frac{u_{bias}}{\sqrt{u_{bias}^2 + u_{proc}^2}}$$

The PFA is then obtained by integrating over the joint PDF:

$$PFA = \int_{L_{up}}^{\infty}\int_{A_{lo}}^{A_{up}} f(d, e_{bias})dd\, de_{bias} + \int_{-\infty}^{L_{lo}}\int_{A_{lo}}^{A_{up}} f(d, e_{bias})dd\, de_{bias}$$

According to the handbook, this double integral is adapted to the standard bivariate normal PDF by dividing the limits by their respective standard deviations and expressed as follows:

$$PFA = \int_{\frac{L_{up}}{u_{bias}}}^{\infty}\int_{\frac{A_{lo}}{u_d}}^{\frac{A_{up}}{u_d}} g(d, e_{bias})dd\, de_{bias} + \int_{-\infty}^{\frac{L_{lo}}{u_{bias}}}\int_{\frac{A_{lo}}{u_d}}^{\frac{A_{up}}{u_d}} g(d, e_{bias})dd\, de_{bias}$$

where

$$g(d, e_{bias}) = \frac{1}{2\pi\sqrt{1-\rho^2}} e^{\left(-\frac{d^2 - 2\rho d e_{bias} + e_{bias}{}^2}{2(1-\rho^2)}\right)}$$

The bivariate normal distribution function can be expressed as:

$$G(h, k, \rho) = \Pr(d \le h \text{ and } e_{bias} \le k)$$

In the integral form this becomes:

$$G(h, k, \rho) = \int_{-\infty}^{h}\int_{-\infty}^{k} g(d, e_{bias})dd\, de_{bias}$$

Finally, according to the handbook, the PFA estimation can be expressed as:

$$PFA = 2\left[G\left(\frac{L_{lo}}{u_{bias}}, \frac{A_{up}}{u_d}, \rho\right) - G\left(\frac{L_{lo}}{u_{bias}}, \frac{A_{lo}}{u_d}, \rho\right)\right]$$

To determine this PFA expression, it was assumed that the Probability of False Acceptance for $e_{bias} < L_{lo}$ is the same as for $e_{bias} > L_{up}$. Hence, the result of the difference between the probability functions is multiplied by 2. This PFA equation is valid as long as the limits are symmetric, but if $|L_{lo}| \neq |L_{up}|$ and/or $|A_{lo}| \neq |A_{up}|$, this equation would give an incorrect PFA estimation.

To get an equation that would apply in all cases, it must be noted that PFA double integrals have defined upper and lower limits:

$$PFA = \int_{\frac{L_{up}}{u_{bias}}}^{\infty} \int_{\frac{A_{lo}}{u_d}}^{\frac{A_{up}}{u_d}} g(d, e_{bias}) dd\, de_{bias} + \int_{-\infty}^{\frac{L_{lo}}{u_{bias}}} \int_{\frac{A_{lo}}{u_d}}^{\frac{A_{up}}{u_d}} g(d, e_{bias}) dd\, de_{bias}$$

Also, it must be noted that the bivariate normal distribution function is expressed as a double integral from $-\infty$ to a specific limit (h or k):

$$G(h, k, \rho) = \int_{-\infty}^{h} \int_{-\infty}^{k} g(d, e_{bias}) dd\, de_{bias}$$

The limit values must be defined correctly in order to cover the same range as the original PFA function. In order to express the PFA integrals in terms of the bivariate normal distribution function, the following conditions must be met:

- The inner integral must cover the range from A_{lo} to A_{up}. This can be achieved by calculating the integral from $-\infty$ to A_{lo} and subtracting this value to the integral from $-\infty$ to A_{up}. This will leave only the probability from A_{lo} to A_{up}.
- The outer integral must cover the range from $-\infty$ to L_{lo} and from L_{up} to ∞. The first can be calculated directly, while for the latter, the integral from $-\infty$ to ∞ must be calculated first, and then the integral from $-\infty$ to L_{hi} is subtracted, leaving only the probability from L to infinity.

Expressing these conditions in mathematical form, the following equation is obtained:

$$PFA = \int_{-\infty}^{\frac{L_{lo}}{u_{bias}}} \left[\int_{-\infty}^{\frac{A_{up}}{u_d}} g(d, e_{bias}) dd - \int_{-\infty}^{\frac{A_{lo}}{u_d}} g(d, e_{bias}) dd \right] de_{bias}$$
$$+ \int_{-\infty}^{\infty} \left[\int_{-\infty}^{\frac{A_{up}}{u_d}} g(d, e_{bias}) dd - \int_{-\infty}^{\frac{A_{lo}}{u_d}} g(d, e_{bias}) dd \right] de_{bias}$$
$$- \int_{-\infty}^{\frac{L_{up}}{u_{bias}}} \left[\int_{-\infty}^{\frac{A_{up}}{u_d}} g(d, e_{bias}) dd - \int_{-\infty}^{\frac{A_{lo}}{u_d}} g(d, e_{bias}) dd \right] de_{bias}$$

By expressing in a simplified form we obtain the expected PFA equation:

$$PFA = G\left(\frac{L_{lo}}{u_{bias}}, \frac{A_{up}}{u_d}, \rho\right) - G\left(\frac{L_{lo}}{u_{bias}}, \frac{A_{lo}}{u_d}, \rho\right) + G\left(\infty, \frac{A_{lo}}{u_d}, \rho\right)$$
$$- G\left(\frac{L_{up}}{u_{bias}}, \frac{A_{up}}{u_d}, \rho\right) + G\left(\frac{L_{up}}{u_{bias}}, \frac{A_{lo}}{u_d}, \rho\right)$$

Since this PFA equation was derived from the integrals, it can be applied in any case regardless if the tolerances or acceptance limits are symmetrical or not.

As a further development, we can notice the expression provided by the handbook is only considering the first two terms of our equation, which cover the PFA value for $e_{bias} < L$. By multiplying this result times 2, the PFA for symmetrical limits is obtained:

$$PFA = 2\left[G\left(\frac{L_{lo}}{u_{bias}}, \frac{A_{up}}{u_d}, \rho\right) - G\left(\frac{L_{lo}}{u_{bias}}, \frac{A_{lo}}{u_d}, \rho\right) \right]$$

III. Example of Application

A 0.100 in grade 3 gage block was calibrated under the Z540.3 standard. The calibration tolerances for this block are -4 μin and +8 μin. The acceptance limits for this unit are -3 μin and 7 μin. The calibration process uncertainty is 2.2 μin for k=2. Calculate the PFA for this unit. Assume a test point measurement reliability of 80%.

The first step is to define all inputs:

$$L_{up} = 8\ \mu in$$
$$L_{lo} = -4\ \mu in$$
$$A_{up} = 7\ \mu in$$
$$A_{lo} = -3\ \mu in$$
$$u_{proc} = \frac{2.2\ \mu in}{2} = 1.1\ \mu in$$
$$Rtp = 80\% = 0.8$$

Then we must calculate the using the following formula:

$$u_{bias} = \sqrt{\left(\frac{L}{F^{-1}\left(\frac{1 + R_{tp}}{2}\right)} \right)^2 - u_{proc}^{\ 2}}$$

where F^{-1} is the inverse standard normal density function.

Since the absolute values for L_{up} and L_{lo} are different, the u_{bias} value is calculated for both cases:

$$u_{bias_{up}} = \sqrt{\left(\frac{L_{up}}{F^{-1}\left(\frac{1 + R_{tp}}{2}\right)} \right)^2 - u_{proc}^{\ 2}} = \sqrt{\left(\frac{8\ \mu in}{F^{-1}\left(\frac{1 + 0.8}{2}\right)} \right)^2 - (1.1\ \mu in)^2}$$
$$= 6.14\ \mu in$$

$$u_{bias_{lo}} = \sqrt{\left(\frac{L_{lo}}{F^{-1}\left(\frac{1 + R_{tp}}{2}\right)} \right)^2 - u_{proc}^{\ 2}} = \sqrt{\left(\frac{-4\ \mu in}{F^{-1}\left(\frac{1 + 0.8}{2}\right)} \right)^2 - (1.1\ \mu in)^2}$$
$$= 2.92\ \mu in$$

Similarly, we must calculate u_d for each u_{bias} value:

$$u_{d_{up}} = \sqrt{(u_{bias_{up}})^2 + (u_{proc})^2} = \sqrt{(6.14\ \mu in)^2 + (1.1\ \mu in)^2} = 6.24\ \mu in$$

$$u_{d_{lo}} = \sqrt{(u_{bias_{lo}})^2 + (u_{proc})^2} = \sqrt{(2.92\ \mu in)^2 + (1.1\ \mu in)^2} = 3.12\ \mu in$$

The correlation coefficient ρ is also calculated for both u_{bias} values:

$$\rho_{up} = \frac{u_{bias_{up}}}{\sqrt{u_{bias_{up}}^{\ 2} + u_{proc}^{\ 2}}} = \frac{6.14\ \mu in}{6.24\ \mu in} = 0.9844$$

$$\rho_{lo} = \frac{u_{bias_{lo}}}{\sqrt{u_{bias_{lo}}^{\ 2} + u_{proc}^{\ 2}}} = \frac{2.92\ \mu in}{3.12\ \mu in} = 0.9358$$

Substituting in the PFA equation that was obtained we get the following expression shown at right.

Finally, the PFA result can be expressed as a percentage:

$$PFA = 0.73\%$$

As observed, the PFA result is below 2% so it is inside the allowable specification.

$$\begin{aligned} PFA = {} & G\left(\frac{L_{lo}}{u_{bias_{lo}}}, \frac{A_{up}}{u_{d_{up}}}, \rho_{lo}\right) - G\left(\frac{L_{lo}}{u_{bias_{lo}}}, \frac{A_{lo}}{u_{d_{lo}}}, \rho_{lo}\right) + G\left(\infty, \frac{A_{up}}{u_{d_{up}}}, \rho_{up}\right) - G\left(\infty, \frac{A_{lo}}{u_{d_{lo}}}, \rho_{lo}\right) \\ & - G\left(\frac{L_{up}}{u_{bias_{up}}}, \frac{A_{up}}{u_{d_{up}}}, \rho_{up}\right) + G\left(\frac{L_{up}}{u_{bias_{up}}}, \frac{A_{lo}}{u_{d_{lo}}}, \rho_{up}\right) \\ = {} & G\left(\frac{-4\ \mu in}{2.92}, \frac{3\ \mu in}{6.24}, 0.9358\right) - G\left(\frac{-4\ \mu in}{2.92}, \frac{-3\ \mu in}{3.12}, 0.9358\right) + G\left(\infty, \frac{3\ \mu in}{6.24}, 0.9844\right) \\ & - G\left(\infty, \frac{-3\ \mu in}{3.12}, 0.9358\right) - G\left(\frac{4\ \mu in}{6.14}, \frac{3\ \mu in}{6.24}, 0.9844\right) + G\left(\frac{4\ \mu in}{6.14}, \frac{-3\ \mu in}{3.12}, 0.9844\right) \\ = {} & 0.0073 \end{aligned}$$

IV. Conclusion

The main purpose of this article was to cover a gap found in the Z540.3 application handbook, as it does not cover the situation when asymmetrical limits are found. An equation that can be used in these cases was developed and presented.

References

[1] *Handbook for the Application of ANSI/NCSL Z540.3-2006 - Requirements for the Calibration of Measuring and Test Equipment.* First Edition. NCSL International.

Pedro Adame (pedro.adame@microprecision.com) received a BS in Electronics Engineering from the Autonomous University of Baja California (*Universidad Autónoma de Baja California*, UABC), Mexico, a MS in Digital Systems from Center of Research and Development of Digital Technology (*Centro de Investigacion y Desarrollo de Tecnologia Digital*, CITEDI), Mexico and a Dipl. degree in Calibration from Center of Engineering and Industrial Development (*Centro de Ingenieria y Desarrollo Industrial*, CIDESI), Mexico. Currently, he works as the lead RF technician for Micro Precision Calibration in San Diego, CA.

The Importance of Adapters in Force Measurement

Henry Zumbrun
Morehouse Instrument Company

Introduction

Think about that for a minute. Would you want a surgeon to operate on you with kitchen utensils such as a serrated knife? There are several force measurement errors that can result from using adapters different from what the force measuring instrument was calibrated with. The basic premise is that mechanical measurements are being made and most adapters used at a laboratory level are going to be manufactured to keep the line of force free from eccentric error and apply the same stresses from adapter interface to force measuring instrument that was done at the time of calibration. Not using the proper adapters to calibrate load cells, truck scales, aircraft scales, tension links, dynamometers, and other force measuring devices can produce significant measurement errors and pose serious safety concerns. Different adapters can change the stress distribution on the force measuring instrument and produce errors that range from minimal to an output difference that produces errors larger than the allowable tolerance.

Other important things to consider are safety and adapters that are not machined properly. Improperly machined adapters may not allow for a distortion free load path. However, they may enable the fixturing the force measuring device in the frame without the end user knowing about the safety factor or other potential errors.

The purpose of this paper is to examine safety concerns with using older adapters and discuss some of the error sources associated with using the wrong adapters. We will leave the rest up to the reader on whether it makes sense to seek out the appropriate adapters and have skilled calibration technicians or simply hope the technician can maintain a "miracle worker" title—though some calibration technicians may still wear a miracle worker hat when the manufacturer writes specifications that were achieved once and never repeated—but I digress as this is an educational paper and we will not be discussing unrealistic specifications. Instead, we will discuss using the adapters that will give a calibration technician the highest probability of meeting those specifications.

Figure 1. Bent Rod End

Old Adapters

Let's start with those old adapters that have been in use for decades. The service life for force calibration adapters depend on several factors including material, design, manufacturing, number of load cycles, and magnitude of each load. There may come a time where the material begins to lose strength, as the result of fatigue, and eventually breaks. Today, there are better material and

Figure 2. Grade 8 Bolt that failed at 120,000 lbf and close to 350,000 load cycles

manufacturing control processes in place that provide more reliable strength values for design engineers than decades ago. There are also computer programs that greatly help in modeling and conducting all kinds of stress analysis. We often get asked what we should do with older adapters? Our guidance is to visually inspect all adapters for any signs of wear or fatigue and replace if they show any signs of potential failure. We recommend replacing adapters that have been in use for more than 20 years or 100,000 load cycles (10,000 calibrations). Adapters today are designed for a life cycle of at least 500,000 load cycles (50,000 calibrations) and failure at close to 1,000,000 load cycles. Now that we have explained some safety recommendations, we can start to discuss some examples where the proper adapters are going to yield better results.

Common Adapters to Reduce Force Measurement Error

Keeping the line of force pure (free from eccentric forces) is key to the calibration of load cells. ASTM E74-18 in note 5 states "Force-measuring instruments have sensitivity in varying degrees depending on design to mounting conditions and parasitic forces and moments due to misalignment. A measure of this sensitivity may be made by imposing conditions to simulate these factors such as using fixtures with contact surfaces that are slightly convex or concave, or of varying stiffness or hardness, or with angular or eccentric misalignment, and so forth. Such factors can sometimes be significant contributors to measurement uncertainty and should be reflected in comprehensive measurement uncertainty analyses." ISO 376 has an entire Annex devoted to force adapters. A good start to what makes a good tension adapter is the ISO 376 standard.

Figure 3. Load Cell showing eccentric forces

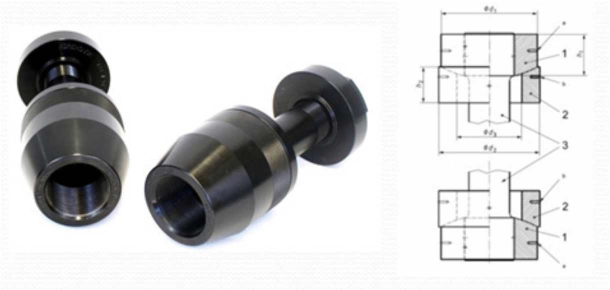


Figure 4. Tension Members with two ball nuts and two ball cups. Tensile force transducers should be fitted with two ball nuts and two ball cups

Annex A.4.1 of the ISO 376 standard says "Loading fittings should be designed in such a way that the line of force application is not distorted. As a rule, tensile force transducers should be fitted with two ball nuts, two ball cups and, if necessary, with two intermediate rings, while compressive force transducers should be fitted with one or two compression pads."

Alignment Plugs for Better Centering

Centering a load cell is critical to obtaining the correct line of force. To make sure the load cell is centered, a proper bottom alignment adapter and other calibration fixtures should be manufactured to match the load line of the calibrating machine. No matter how good an operator may be, they are no match for something machined with precision. By having bottom adapters with concentric rings for alignment or alignment plugs to perfectly center the force-measuring instrument, the end user is going to be able to reduce misalignment error.

Why is it critical to reduce misalignment error? Pictured in Figure 6 is a test showing the spherical adapter without an Alignment Plug. The error observed is 0.752 % on S-Beam load cells with less than 1/8" misalignment. When the load cell was aligned and calibrated properly, the expanded uncertainty was calculated at about 10 lbf, when the load cell was misaligned, the expanded uncertainty became approximately 90 lbf. It is quite a bit of difference on a 10,000 lbf s-beam load cell. If the technician misaligned the load cell in a testing machine, they may end up adjusting a machine that is actually "in tolerance" and a recall may

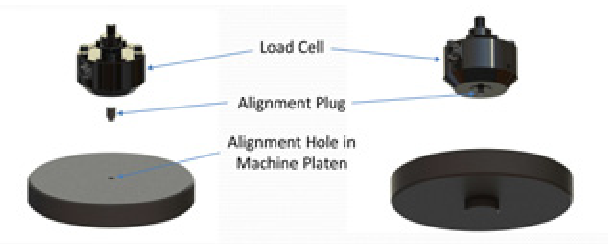


Figure 5. Morehouse Alignment Plugs

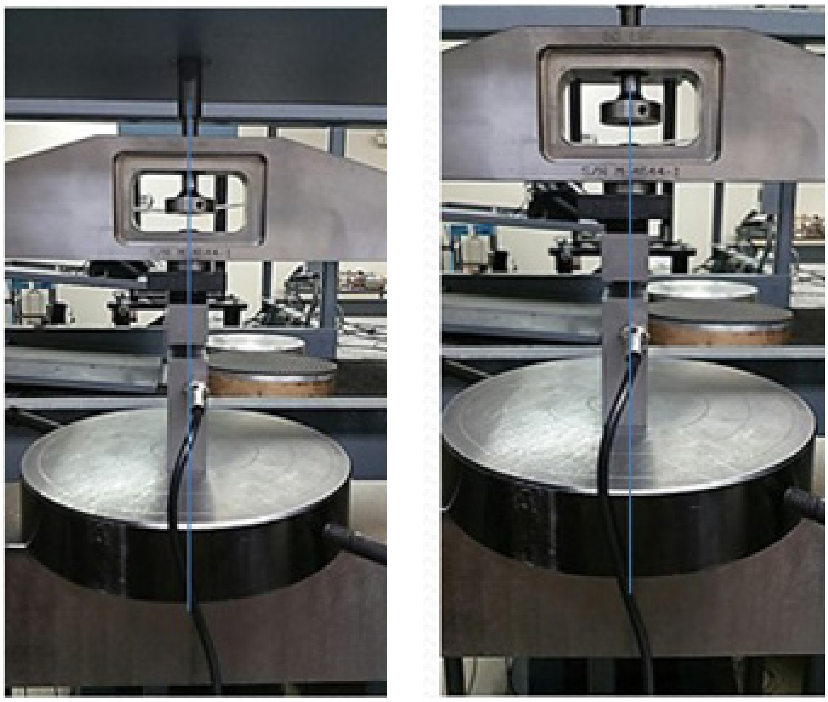


Figure 6. S-beam load cell with slight misalignment producing a 0.752 % error

result from this simple to make error. Alignment plugs and base plates with alignment holes in Figure 5 drastically reduce misalignment error.

Another error source is not knowing what adapter to use in compression tests. The recommendation is to use a spherical alignment adapter and alignment plugs for any load cell with a female thread that needs to be calibrated in compression. For a shear web load cell, we recommend installing the integral threaded adapter. The shear web load cell is very susceptible to varying thread engagement and the integral adapter eliminates this error. For those that still need to use a shear web type cell and have height restrictions, a spherical adapter is recommended, but will not produce results equivalent to that of an integral threaded adapter. The errors from varying the thread length of adapters in load cells can be as high as 0.5 %.

Figure 7. Morehouse Button and Washer Load Cell Adapters

Common Compression Adapters for Button and Washer Type Cells

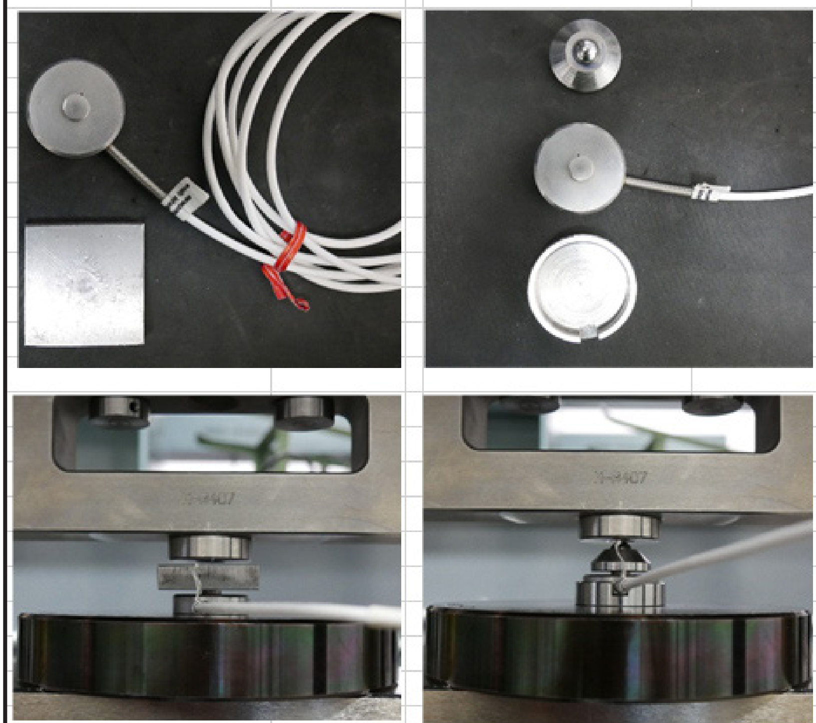
The number one complaint with button and washer load cells is how to get them to repeat between rotations. These load cells are notoriously sensitive in rotation and any misalignment will produce large errors. The sensitivity to off-axis or side loading conditions is quite high. High enough that 0.1 % of misalignment is going to produce a rather large cosine error. The error can sometimes be as large as 10 % of rated output. We typically find this error to be between one and two percent in well aligned deadweight machines. Below are pictures of button and washer load cell adapters which improve alignment and yield better calibration results. Usually the results are better by a factor of 5 or more when using the adapters, as compared with a technician trying to center as shown in Figure 8. The picture on the left-hand side of Figure 8 shows a typical setup in which it is nearly impossible to get the readings to agree within 0.5 % when repositioning the button load cell. The picture on the right is using adapters to help improve alignment and yields much better results.

The data in Figure 8 shows a 525 % improvement in rotation using the proper alignment adapters. The reproducibility error went from 1.045 % to 0.199 %. It is worth mentioning that most button load cell systems cannot achieve better than 0.25 % of full scale even with the proper adapters. We have seen some specifications where the end user is expecting 0.1 % of full scale or better. Without the proper adapters, 1 percent of full scale is nearly impossible to achieve. Proper testing would involve putting the unit back into the machine and demonstrating agreement between the tests. With the Morehouse Adapters, reproducibility of better than 0.25 % is possible as demonstrated. To achieve these results, the button load cell must not be damaged or have wear patterns. Those cells with wear patterns are going to have much larger errors. The adapters in Figure 7 will improve those results as well, but these adapters will not turn a worn button load cell with a 5-10 % error into a cell with an error of better than 0.5 % of full scale. In general, we see improvements with a magnitude of 2 - 10 times better when using the proper adapters. These adapter sets can also accommodate alignment plugs to align the whole calibration setup with the calibration machine; a deadweight system, hydraulic Universal Calibrating Machines (UCM), or Portable Calibrating Machines (PCM).

Tension Clevis Adapters for Tension Links, Crane Scales, and Dynamometers

If the calibration lab then decides to use a pin that is different from manufacturer's recommendations, there will be larger than expected bias. In fact, most manufacturers will agree on the following: using correctly sized pins is critical; do not use pins that are worn or bent; if the links are damaged, highly used, or worn, decrease the time between calibrations; and the same size and style of shackle and pin used during operation should also be used for calibration. To demonstrate the error in pin size, we loaded a tension link in our Morehouse deadweight machine with accuracy of better than 0.002 % of applied force and loaded to 50,000 lbf with two different size load pins. When loaded with a smaller pin of 1.85 inches, the device read 49,140 compared to being loaded with a 2-inch pin and reading 50,000 lbf. When the end user does not send in an adapter, the calibration laboratory is left with having to load the device with some pin. The important thing to remember is that the calibration should be performed with the same load pins the end user is using with the device. If the end user does not send their adapters, the calibration lab must try and match the manufacturer's recommendations.

Standard Setup versus Morehouse Adapters in Morehouse Deadweight



Manually Aligned	Data
0 degree	2011
120 degree	1997
240 degree	2018
Average	2008.66667
Standard Deviation	10.6926766
Max Deviation	21
% Error	1.045%

Aligned with Adapter	Data
0 degree	2008
120 degree	2006
240 degree	2010
Average	2008
Standard Deviation	2
Max Deviation	4
% Error	0.199%

Figure 8. Typical button load cell calibration versus one with Morehouse Adapters

However, finding the right pin size can be tricky as the manufacturer's recommendations may be counterintuitive. For example, a 20-ton tension link may require a 2.0-inch pin and a 25 ton may require a 1.97 (50mm) pin. One may say 0.03 inches will not make a difference and we would say go ahead and test it. On a device with an accuracy specification of 0.1 % of full scale, we have observed a change of 0.03 inches to use up 70 % of that specification.

Knowing these issues, Morehouse has designed clevis assemblies for use with our Quick-Change Tension Adapters, as shown in Figure 10. These assemblies cross reference the manufacturer's recommended pin size and allow the calibration laboratory to calibrate hundreds of tension links, crane scales, dynamometers, and rod-end load cells all with using the same clevis. Not only does this simplify the logistics of having the proper adapter, but it improves cycle time and standardizes the calibration process.

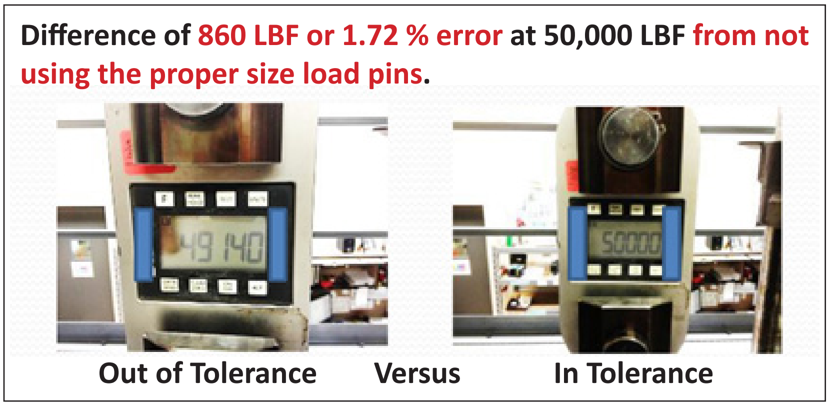


Figure 9. Tension Link Difference in output with pin size

Conclusion

Most force measuring instruments are susceptible to misalignment error, errors from not exercising the force measuring instrument to full capacity, and errors from improper adapter use. In almost all cases, there will be additional errors if the end user fails to have the force measuring instrument calibrated with the same adapters used in their application. When evaluating other error sources, it is important that the end user of the force measuring instrument is replicating how the force measuring instrument was calibrated or that the laboratory performing the calibration is replicating how the instrument is going to be used. Fixturing and adapters used with the force measuring instrument may have a significant contribution to the overall uncertainty of the force measuring instrument. From the examples provided in this paper, these errors can be quite large and produce large measurement errors that are over twenty times greater than the instrument's accuracy specification.

Morehouse has conducted extensive testing throughout our ninety-five plus years of making force equipment. We have reference force standards with calibration and measurement capabilities of better than 0.002 % to conduct many tests on adapters and provide solutions that improve measurements for our customer base. The frightening part of this is that not everyone in industry is part of our customer base and several do not realize they have these errors. Can you imagine the company making critical measurements using a misaligned S-Beam load cell? How about weighing something like a ton of uranium with a tension link using the wrong size pin? These measurements matter and can impact our safety! Please join us in educating the people who underestimate the importance of adapters and help us create a safer world by helping companies improve their force measurements.

Henry Zumbrun (hzumbrun@mhforce.com), Morehouse Instrument Company, 717-843-0081, www.mhforce.com.

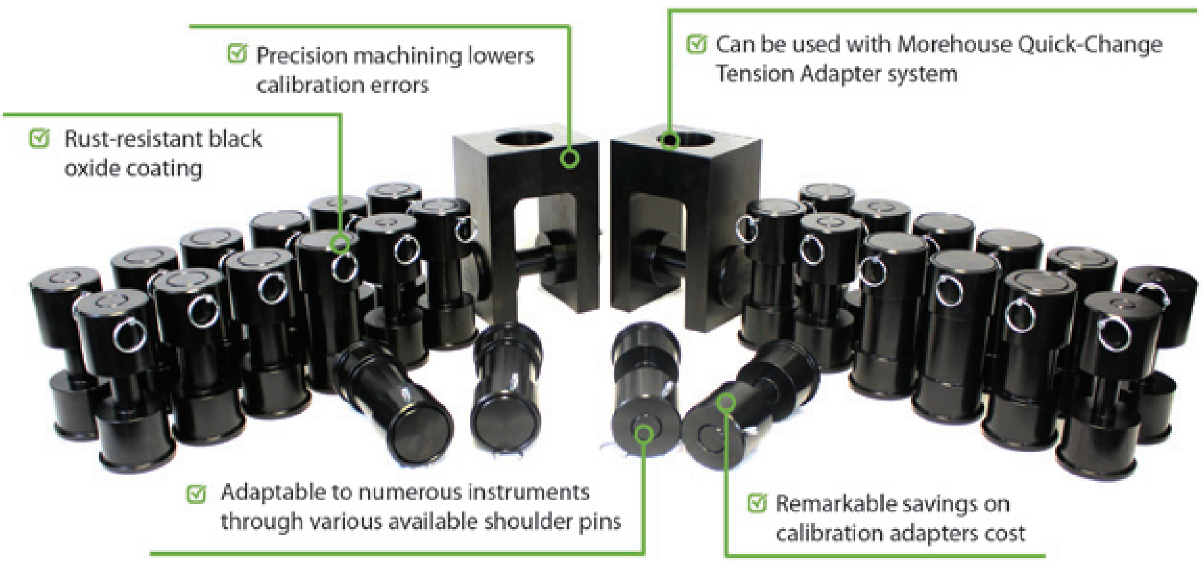


Figure 10. Morehouse Clevis Kits

Creating Sustainable Metrology Software

Michael L. Schwartz
Cal Lab Solutions, Inc.

We are currently in a 30 year old software rut. There is nothing new on the market designed specifically for metrology. This paper is on both the direction the rest of the software industry is headed and how we adapted those trends to metrology software problems. This paper outlines how we de-siloed our software development and moved to a more sustainable solution.

Introduction

I have had lots of conversations and read several papers and articles related on creating a standard for exchanging calibration data between systems. This is a goal many of us metrologists share. Though each of us has a slightly different perspective of the technologies used and overall implementation, we can all agree this is something the industry needs.

Most of this paper will outline the direction Cal Lab Solutions is headed with our new Metrology.NET® system. It is important to note, Metrology.NET was built as a "System of systems" solution, meaning "it is a collection of task-oriented or dedicated systems that pool their resources and capabilities together to create a new, more complex system which offers more functionality and performance than simply the sum of the constituent systems [1]." From the start, our goal was to build an infrastructure that allowed the community to work together without being tied into a single manufacturer, software platform, operating system or database.

Software Drives Hardware Sales

Today, just about every calibration standard you purchase comes with some form of software. And in many cases, it is the software enhancing the value of the hardware; it is the software that makes the hardware work better. So many manufacturers offer a software package with their hardware with varying degrees of success.

The disadvantage of this is that it can create tons of customization and manual steps to manage the variations. A calibration lab will have to install software package one, train technicians how to use it and how to get the data back into their lab management system, then repeat it for software package two, three, four, and so on.

Manufacturers will always write software, after all, they know how to best use their hardware. But it doesn't have to be the Wild-West of software; we can create standards and share resources. We don't need to keep reinventing the wheel.

Sustainable Software

One of today's buzzwords is 'Sustainable Software,' but what does that really mean? Most of the definitions I have found focus on the development aspect of Sustainable Software, but I see it in a bigger picture. Sustainable Software is the concept of standing the test of time; software systems that can grow, expand, and transform as technologies change.

Over the years, I have worked on several projects with different engineers. Every engineer has their favorite programming language. I have even witnessed engineers quit a team because the team chose a different language than the one he liked. So my first requirement of Sustainable Software is it can't be tied to a single programming language.

And, Sustainable Software can't be tied to a specific operating system. Imagine if you designed all your code to run only on the Apple Servers in the 1990s. We don't know the future and how the operating systems will change computing, but we can prepare for change.

For metrology, we have to support different standards, test process, communication protocols, soft-instruments and the Internet of Measurement Things (IoMT). As equipment becomes more feature packed, we need a different way to manage flexible drivers that is sustainable. Today's oscilloscope is also an arbitrary waveform generator, a spectrum analyzer, and a digital voltmeter. Hybridized instruments like this are becoming commonplace, and harder and harder to classify into equipment types.

Change is coming and coming faster than ever before, as product development cycles decrease. 30 years ago, an idea to a product took years. Today, with a 24 hour development process moving around the world, it only takes a few months to have a product ready for the market and the pace is only going to increase.

Direction & Technology

We created the Metrology.NET® trademark around the idea of Data Exchange Between systems. The NET is about creating networks of data systems that work together and share resources (system of systems) with the long-term goal of creating a trade association for metrology data systems.

But we needed more than trademarks and great ideas! We needed to build technologies that both worked and were sustainable. And we had to do it with mixed technologies, software platforms, backend databases and multiple companies.

We modeled our design off the airline industry's reservation systems. They have well defined standards that allow you to use just about any travel website to book a reservation of any airline. That is what we wanted to do for metrology, as described in Mark Kuster's article "Metrology: Standardize and Automate [2]!"

At the center is REST (REpresentational State Transfer). This technology allows data to be passed from system to system regardless of the programming language. Just about all web technologies are built on REST technology.

Next, we wanted the server software to be able to run on any operating system. After researching several technologies, we settled on JAVA, Apache TomCat, and MIBATIS (all open source technologies). We chose MIBATIS because it allowed us to communicate with several databases and tested it with PostgreSQL, MySql and SQL Server. We liked PostgreSQL best because it allowed clustering.

Researching the calibration labs, we found that more than 99% of them are running some form of MS Windows on their workstations. This made technology selection simple so we chose Microsoft .NET 4.0 because it supported several programming languages, allowing engineers to select their preferred language. We were also able to connect directly to the VISA libraries, allowing us to support any IEEE 488.2 compatible GPIB card. We have tested it with National Instruments, Keysight, and Advantech GPIB cards.

Foundation

While calibrating an HP 5600A scope 30 years ago, while playing a game of Tetris, I thought of a way to make metrology better. Why can't we use this extra space in the scope to store the calibration data and maybe even the whole calibration procedure? Then it hit me: just put a data table in the scope that contains all the test points. Download the test points to the workstation process, make the required measurements, then upload the results back to the scope or other unit under test. Now keep in mind this was the early 90s and the US Army in Korea had ZERO automated calibration procedures.

Over the past 20 years, we have been working to refine this concept. What I didn't know back then was the overall complexity of a test point and how to abstractly define a generic test process (the Metrology Taxonomy) and embed that into the test point. What has helped us refine our abstraction is the work we have done with the NCSLI 141 Measurement Information Infrastructure and Automation Committee. With the cooperation of that group, we have worked to create a method of creating a solid foundation for Metrology Taxonomy [3].

We have a sustainable foundation from this work. What we have learned is the value is not the automated script that runs the calibration, but the detailed data about what you are testing and the system of systems standardization. How do we know our software architecture is sustainable? Simple. We can automatically write 75% of a Fluke MET/CAL® procedure from the Metrology.NET® data and, with some tweaks, it is possible to output into any programming language.

Abstraction

Abstraction starts with the Test Point (see Figure 1). We have to think of a calibration as a set of test points; we have to collect data on all these test points, then the calibration is complete. Each test point is a self-contained entity containing everything we need to know to collect data against the test point. This allows us to organize and group the test points in several different ways like Test Groups, Channels, or station.

In each test point, we have to have the following minimal information: nominal value, unit of measure, resolution, upper and lower limits. We can optionally add the line number out of the manual that the test point applies to. This allows us to specifically tie the test point to a physical document the calibration technician can use to run an automated calibration.

If we want to fully automate the calibration, we will have to add additional test data and instrument settings for each test point. This is data that the automation scripts will interpret and use to perform the calibration. I use the word *interpret* purposefully, because to make truly sustainable software, you can't code specifically, because you don't know all the possible options.

For our focus, I will use an AC voltage example for calibrating an Agilent 34450A DMM. And, for a generic test process of "Source.Volts.AC.Sinusoidal," the Metrology Taxonomy requires us to provide both Volts and Frequency, so each test point will have these interpretable test settings. Later in the test process, these values will be used to first determine whether the calibrator can perform the test point, then the specific settings required to set up the calibrator.

It is also important to note, 'interpret' can also mean the test process can make changes to the test point. If we needed more accuracy and chose to monitor a less accurate calibrator with an AC Voltmeter, we may not get the exact value, so the nominal value may change slightly. This is why the test point definition has to be an abstract definition.

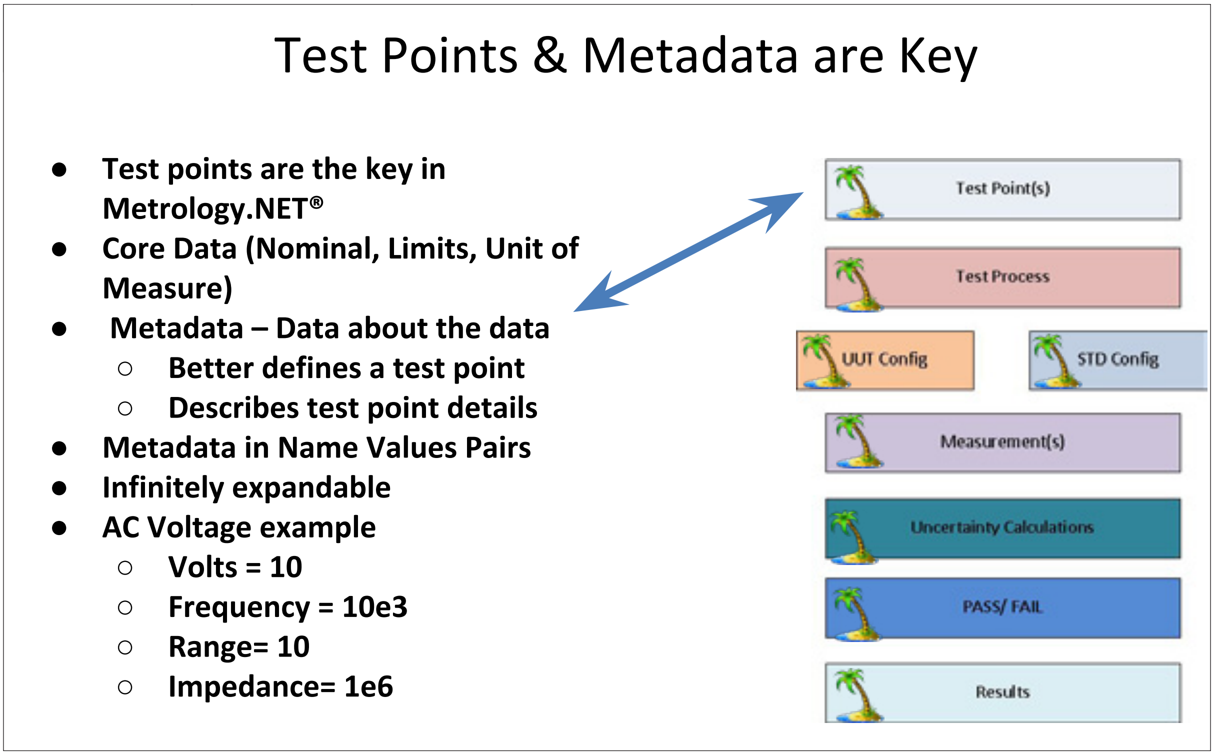


Figure 1. Test points are key to automating calibration. By adding instrument settings and measurement parameters, any software can be written to make the measurements. Keeping the blue line (the communications and data standard) simple and transportable is key to a system of systems design, because it does not rely on any specific technology.

Taxonomy

Metrology Taxonomy is a new concept being introduced to the industry. The goal is to move away from an instrument level/flexible standards type of abstraction to a more process oriented model. For example, using the flexible standard model would allow you to change a Fluke 5520A with a 5720A for something like sourcing volts AC, but it wouldn't allow you to swap a Fluke 5720A with a 5500A monitored by a Fluke 5790A. The measurement process is different; the hardware configuration is different!

By adding an extra layer of abstraction, the "Metrology Taxonomy" layer provides for greater flexibility. Having a flexible process model like "Source.Volts.AC.Sinusoidal" instead of a flexible standard model allows you to swap different measurement techniques and hardware configurations. This allows you to use a Fluke 5720A in a single calibrator model or a less accurate 5500A monitored by a 5790A.

Metrology Taxonomy is at the heart of Sustainable Software and the Metrology.NET system of systems architecture. The taxonomy defines the required information for each test process type. Then, from the generic definition the specific implementation, "The Calibration Process" is created, complying with the standard requirements and interpreting the test point's requirements.

Calibration Process

The Calibration Process can be thought of as the LEGO bricks in the system of systems. Once you have the Test Point containing the test setting and Metrology Taxonomy, how you test it is a matter of what color of LEGO do you want to use—what standards do you have right now that can perform the test?

Writing an automated calibration process is usually the job of the metrology/automation engineer. It is imperative that the process complies to the Metrology Taxonomy requirements. The metrology engineer will know both the generic aspects of the test, as well as the specifics of the hardware used to get the best results for each test point. The calibration process must interpret the test point and instrument settings, then set up the hardware correctly to perform the calibration. It sounds complex, but all the engineer has to do is write a Run() function. Complexities like I/O, CPU threading, reporting, and formatting are handled by shared tools.

Uncertainties

Uncertainties are where the interchangeable metrology taxonomy/calibration process model shines! Because not all calibration processes are created the same, they require different uncertainty models.

The metrology engineer is able to write the uncertainty model right into the calibration process. Yes, they can do that in the other scripting languages out there, but in this model, that test process is attached (connected like a LEGO) to the test point when it is tested. So, it is in one place, fixed one time and it is applied everywhere, on every UUT!

But wait, there's more! In our systems-of-systems architecture, we allowed for an additional/optional uncertainty calculator to be added and called after each test point. This allows for faster compliance to changes in standards like ISO/IEC17025. Imagine that, meeting compliance to a change in the standard in hours instead of months. And with just a couple tweaks to the spreadsheet you gave to your auditor, that same spreadsheet could be used to calculate your uncertainties.

Simplifying Automation

All of this sounds extremely complex, but the system as a whole was built to simplify automation. We do this by breaking things down into three easy steps, Test Points, Test & Instrument setting, and VISA Script with MetrologyBlocks™.

Test Points. The test points will have to be added in any data collection system; there is no way around that step. Even if your data points come from a script, you will have to add them to the script or a data file the script reads.

Test & Instrument Settings. Typically, these would be embedded or added to the automation script and the automation script would be written based on the UUT manual, around a specific set of standards. Here, we want to think about all the settings and add them to the test point's settings. Even if they are not immediately used, they provide valuable information about what is getting tested. In the "Source.Volts.AC.Sinusoidal" example, there is an optional Impedance go ahead added to it because someday we may want to test it with a calibration process where Impedance is important for the instrument settings or uncertainty calculations. You can never have too much data about the test point.

VISA Script with MetrologyBlocks™. We discovered that every UUT can be abstracted into five function calls (Reset, Setup, OutputOn, OutputOff, and Measure). This made it super easy to write a Run Function that worked with ANY UUT. Because we didn't want to require our Metrology Engineers to have to write every UUT procedure, we needed a simple UI to help the less technical user create automation.

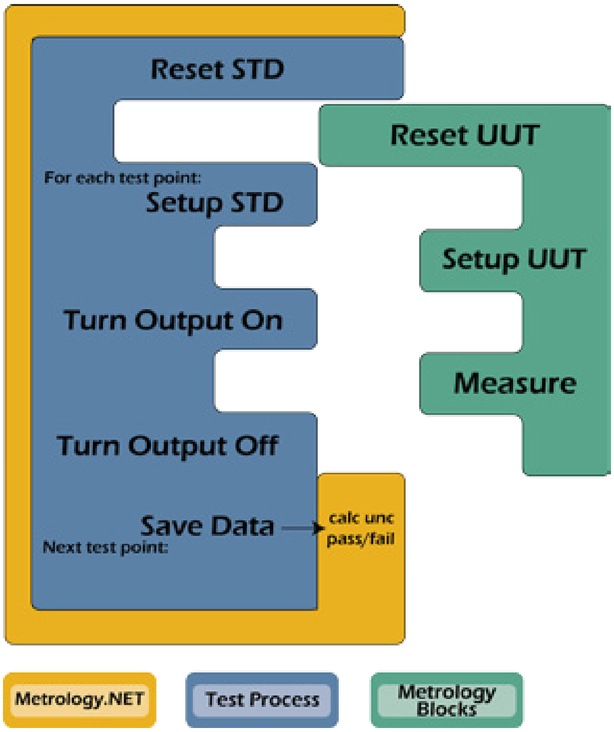


Figure 2. Standardized test processes calling a simple UUT based, flexible driver allow for faster procedure development.

So we added VISA Script and MetrologyBlocks™, which is perhaps the chrome plating on the whole system. This user interface allows the less technical metrology technician to create automation with a graphical user interface that will generate a correctly formatted VISA Script. This frees up time for the metrology engineer to work on more complex tasks.

Flexibility

This allows for ongoing integration and flexibility. Imagine you have a full test package with all the test points for an Agilent 34450A. You have run this calibration several times with a Fluke 5520 and Fluke 5720. But then your boss goes out and gets a great deal on a new calibrator, for example, a Transmille 4011 calibrator. There is no need to rewrite any software—simply drop the Transmille_4011.dll driver in the drivers directory and you are calibrating 34450A meters within minutes.

This is the core of a system of systems architecture. You can add to it simply and completely replace it as needed. It is just a module, a LEGO, mixed and matched with other modules all working together.

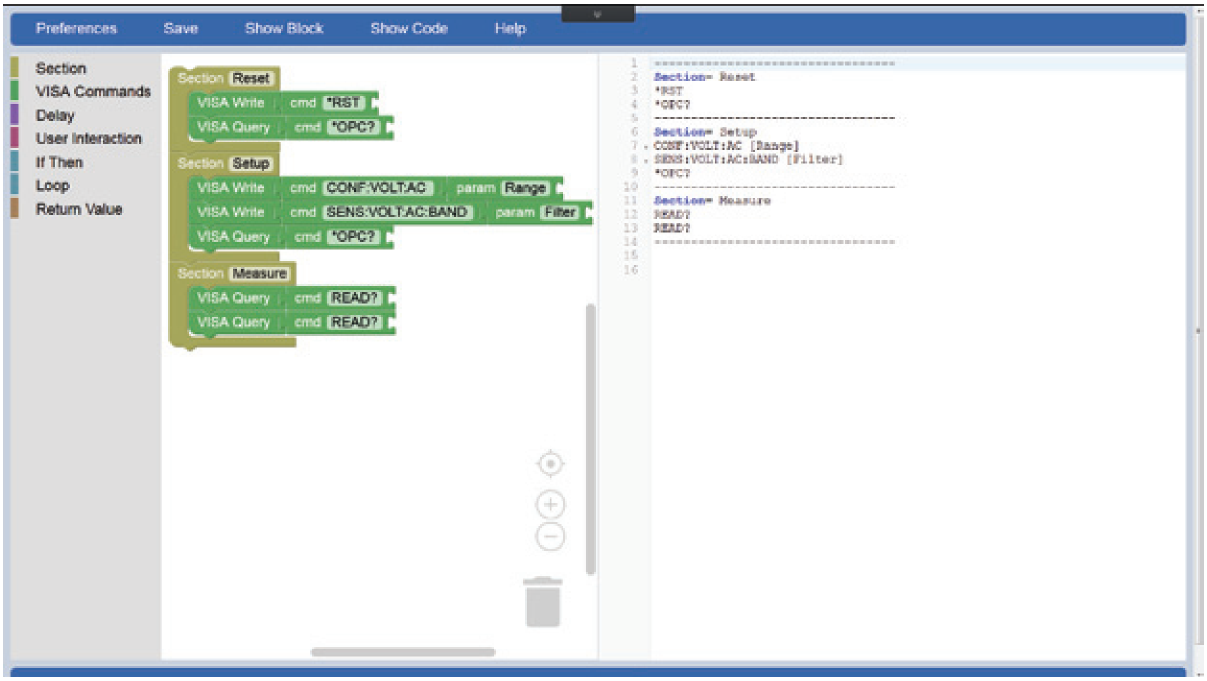


Figure 3. VISAScript is a simple scripting language for developing UUT VISA resource drivers. Metrology Blocks™ makes building VISAScript fast and easy. This handy tool was designed by Spark Calibration Services in cooperation with Middle East Technical University (METU).

The Future

To talk about the future, I have to talk about the past. Nothing new has been created in software that wasn't created in the 1950s and 60s, including Artificial Intelligence and blockchain. What is new is how people look at the technology and implementation.

And when it comes to creating an industry standard, it is more about adoption than technology. The best example of this it USB vs. Firewire. Yes, Firewire is a superior technology, but USB is everywhere. This example also highlights the value in an open and free standard.

I know several companies will adopt this technology, or something similar, and then call it unique as they try to trademark it or patent it. This is part of the reason I am writing this paper now. I, like many others in the industry, want a metrology data standard used to exchange data between systems. I want to see that concept expanded to a system of systems solution for metrology that can do more than just exchange data. With all of us in the industry working together we can create a flexible, sustainable, software model!

References

[1] https://en.wikipedia.org/wiki/System_of_systems

[2] M. Kuster, "Metrology: Standardize and Automate!," *CAL LAB: The International Journal of Metrology*, Vol. 20:2 (Apr 2013), pp.26-34.

[3] H. Eilers and M. Schwartz, "Rules & Tools for Creating a Metrology Taxonomy," *CAL LAB: The International Journal of Metrology*, Vol. 25:4 (Oct 2018), pp.32-35.

Michael L. Schwartz, Cal Lab Solutions, Inc., PO Box 111113, Aurora, CO 80042, MSchwartz@CalLabSolutions.com.

Vaisala Introduces CAB100 Industrial Cabinet for Cleanrooms

Vaisala CAB100 Industrial Cabinet for Continuous Monitoring System (CMS) is ideal for data collection specifically in cleanrooms, and in other demanding industrial environments. It integrates Vaisala's data loggers, analog signal data collection and differential pressure transmitters in a single enclosure with a high IP-rating and easy-to-use design.

The CAB100 is an add-on part of Vaisala viewLinc Continuous Monitoring System. The monitoring system integrates data loggers, transmitters and monitoring software to monitor several parameters, and provides real-time and historical measurement data, customizable reporting, and reliable alarming to email, SMS, and local or PC display.

"The Vaisala viewLinc Continuous Monitoring System is used globally in pharmaceutical and biotechnical companies to fulfill their Good Manufacturing Practice, also known as the GMP-requirements," says Vaisala's Product Manager Steven Bell. "The CAB100 cabinet is a great addition to the viewLinc monitoring system, as it makes the installation of the application-optimized instrumentation much easier. This is essential for example in cleanrooms where the cleanliness is important and installation of any equipment inside the clean area has limitations."

The CAB100 cabinets are configurable according to the application requirements, with various options for measurement inputs and safety barriers to instrumentation used in hazardous areas. The powering options include integrated power supply for mains powering or Power over Ethernet (PoE).

Vaisala is a global leader in weather, environmental and industrial measurements. Building on over 80 years of experience, Vaisala provides observations for a better world. We are a reliable partner for customers around the world, offering a comprehensive range of innovative observation and measurement products and services. Headquartered in Finland, Vaisala employs approximately 1,850 professionals worldwide and is listed on the Nasdaq Helsinki stock exchange. vaisala.com, twitter.com/VaisalaGroup

IET Labs PRS-330 Programmable Decade Resistor and PRS-370 Self-adjusting Programmable Resistor

April 30, 2019 - IET Labs has released the PRS-370 and PRS-330 to meet the ever-growing demand to automate source resistance in calibration laboratories and production environments.

The PRS-330 dramatically improves the most important aspects of the earlier manual resistance decades. It introduces an advanced algorithm to create an easy to use programmable decade resistor with 30% improved accuracy, <70 ppm and 1000 times better resolution, 1 μΩ, or 6 digits, than traditional laboratory decade boxes and RTD Simulators.

The PRS-330 comes standard with USB, Ethernet, IEEE 488 interfaces, and user-selectable front and rear binding posts.

The large color touchscreen and intuitive interface promotes little to no training and simplifies manual use.

The PRS-370 was explicitly designed for calibration laboratories, and when used with a Fluke 8508A or Keysight 3458A can achieve an accuracy of <10 ppm. This makes the PRS-370 a short-term stable programmable standard of resistance.

The PRS-370 makes sure you always have the right resistance standard to calibrate new instruments.

The PRS-370 features an IEEE-488 interface that can either control the 8.5 digit DMM or be controlled via PC. The easy to read graphical color touchscreen shows the target resistance, Δ from nominal, measured resistance from the DMM and the measurement accuracy of the DMM.

Benjamin Sheena, Worldwide Sales Manager for IET Labs, says, "The PRS-370 will make you rethink, the decade resistor, extremely tight accuracy, no long-term maintenance costs, and leverages the performance of the 8.5 Digit DMM you already own. IET Labs received U.S. Patent 10,191,084 due to the significant advancements the PRS-370 has over existing programmable decade resistors in the market today."

With its industry leading 5-year warranty all aspects of the PRS-330 and PRS-370 are focused on reliability, reduced ownership costs and simplicity out of the box.

IET Labs is proud to manufacturer the PRS-330 and PRS-370 in the USA.

IET Labs, is a leading provider of Decade Resistors, Inductance and Capacitor Standards, Megohmmeters, Stroboscopes, and LCR Meters.

For more information see:

- PRS-330 Programmable Decade Resistor https://www.ietlabs.com/prs-330-programmable-decade-resistor.html
- PRS-370 Self-adjusting Programmable Resistor https://www.ietlabs.com/prs-370-programmable-decade-resistor-1.html

For further information contact: IET Labs, Inc., 1 Expressway Plaza Roslyn Heights NY 11577, 516-334-5959 info@ietlabs.com

NEW PRODUCTS AND SERVICES

CNS Harmonic & Flicker Analyzers

Poway, CA, April 16, 2019 - CNS Inc. has released the IEC 61000-3-2/3/11/12 compliant HFA series of harmonics & flicker analyzers for current ranges up to 75 Amp/phase. The software is fully compliant with the most recent versions of the standards and 2 year no-cost support for standards updates is included.

All HFA versions have 6 high speed parallel 16 bit A/D converters and allow spectrum analysis to 10 kHz. The systems interface to PC's via a USB port, and can be operated with laptop and desktop PC's running Windows-7/8/10.

The display and test report show the waveform and harmonic spectrum, as well as numerical values vs. limits for each 200 ms measurement window in accordance with the standards.

The small form factor HFA-1 is ideal for on-site pre-compliance testing using the public supply @ 100/120/220/230 Volt 50/60 Hz, or for full compliance testing when combined with a suitable AC power source. Prices for the single phase small form factor analyzer with an ISO-17025 accredited calibration certificate start at under $6,000.

The 19" rack version in either 1 or 3 phase configurations can be used in automated compliance test systems. Options include a built-in Reference Impedance per IEC TR 60725 or the Z-test per IEC 61000-3-11. Prices for the 19" version with ISO-17025 accredited calibration certificate start at under $10,000.

With more than 30 years experience in harmonic and flicker analysis, and participation in IEC standards committees since 1996, CNS Inc. offers a unique combination of standards knowledge and cost effective design expertise for hardware and software of harmonics and flicker analysis and calibration products.

CNS Inc. has provided accredited calibration services to every major IT equipment and electrical products manufacturer in the USA, as well as for many international EMC test houses. CNS Inc. also supports many clients in Asia, and was instrumental in the generation of IEC technical reports for on-site calibration of harmonics test systems per IEC TR 61000-4-37 and flicker calibration per IEC 61000-4-38.

For more information, contact mathieu@cnspoway.com

Additel 286 Multifunction Reference Thermometer Readout

Brea, Calif., April 25, 2019 – Additel Corporation introduces their new ADT286 Multifunction Reference Thermometer Readout which combines a high-end reference thermometer with an expandable data acquisition system and an 8.5-digit multi meter. The ADT286 is capable of scanning and recording up to 82 channels at 10 channels per second. Users can easily configure the ADT286 to perform field calibrations and uniformity studies as well as use the ADT286 in the lab as a precision thermometer and 8.5-digit multi-meter.

Each unit comes standard with a 10.1" color touch screen display, imbedded auto temperature control for Additel and other manufactures heat sources, as well as full support of SPRTs, RTDs, thermistors & thermocouples. Optional accessories are available to support up the 82 measurement channels for support of environmental testing and temperature surveys as well as a reference resistor to provide support for SRPT ratio mode measurement with uncertainties as low as 1 ppm. Bluetooth, USB & Ethernet (RJ-45) communication capabilities are also included.

Product Availability

The Additel 286 and all related accessories are now available for order. For more information, please visit www.additel.com. For information on Additel products and applications, or to find the location of your nearest distributor, contact Additel corporation, 2900 Saturn Drive, #B, Brea, CA 92821, call 1-714-998-6899, Fax 714-998-6999, email sales@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 and temperature calibration as well as test instrumentation. With more than 18 years in the industry, Additel has successfully developed Dry Well Calibrators, Temperature Readouts, 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.

Keysight Technologies Phase Noise Test System

SANTA ROSA, Calif., May 30, 2019 - Keysight Technologies, Inc. (NYSE: KEYS), a leading technology company that helps enterprises, service providers and governments accelerate innovation to connect and secure the world, today introduced a new phase noise measurement system for "power users" which enables them to optimize and prove performance of new designs, meet operational requirements, as well as remain on schedule and on budget.

Phase noise is an unwanted phase modulation noise that emerges in nearly all radio frequency and microwave devices including oscillators, mixers, dividers, multipliers and amplifiers. Power users, including professionals responsible for developing high-performance aerospace and defense applications as well as cutting-edge device characterization for 5G and other wireless communication systems, need to validate the phase noise performance of their designs.

Keysight's new N5511A Phase Noise Test System (PNTS) models are available in three frequency ranges - from 50 kHz and going up to 3, 26.5, or 40 GHz with offsets from .01 Hz to 160 MHz internally. It can be configured for either single or dual-channel operation and offers the following key technology features:

- Flexible architecture for easy integration of external reference sources enabling users to select from a variety of commercially-available low-noise sources
- Phase detector (quadrature) technique maximizes dynamic range
- Best-in-class absolute and residual measurements on both continuous wave and pulsed signals
- Cross spectral averaging (cross-correlation) to measure noise approaching the limits of physics, down to the kT (–177 dBm/Hz) thermal noise floor, by removing uncorrelated noise between two channels and enabling users to see the real performance of their device under test

Consisting of phase detector and data conversion modules housed in a custom, low-noise single PXIe mainframe four units (4U) high, the N5511A occupies minimal rack space. The system software included runs on an integrated PC controller using the Microsoft Windows 10 operating system.

Pricing and Availability

N5511A Phase Noise Test System is available now. Prices start at USD $135,000.

Additional Information

More information is available online at www.keysight.com/find/PNTS and www.keysight.com/find/N5511A.

Rohde & Schwarz FSV3000 and R&S FSVA3000 Spectrum Analyzers

Munich, April 11, 2019 — Rohde & Schwarz is launching two new signal and spectrum analyzer families, with different frequency models covering up to 44 GHz.

The R&S FSV3000 is designed to help users set up complex measurements in the simplest and fastest way possible. With its easy usability and high measurement speed, it is the right instrument for labs and production lines. It provides up to 200 MHz analysis bandwidth – enough to capture and analyze, for example, two 5G NR carriers at once.

The R&S FSVA3000, with up to 400 MHz analysis bandwidth, a high dynamic range and an outstanding phase noise of –120 dBc/Hz, delivers performance that was, until recently, reserved for high-end instruments. It enables users to perform highly demanding measurement applications such as linearizing power amplifiers, capturing short events and characterizing frequency agile signals.

Both the R&S FSV3000 and R&S FSVA3000 can measure EVM values better than 1 % for a 100 MHz signal at 28 GHz. Together with the coverage of the 5G NR frequency bands up to 44 GHz, this makes the analyzers ideal for analyzing 5G NR signals.

The R&S FSV3000 and the R&S FSVA3000 spectrum analyzers simplify troubleshooting rare events and setting up complex measurements. With the event based action GUI, whenever a predetermined event occurs the corresponding action, such as saving a screenshot or I/Q data, is performed.

In scenarios with automated production lines with complex measurements, external computers can take over the control of the instruments via SCPI commands. Furthermore, the embedded SCPI recorder makes it much easier to create executable scripts, since all manual input is translated into plain SCPI or into the syntax of common programming languages or tools such as C++, Python or MATLAB©.

The R&S FSV3000 and the R&S FSVA3000 spectrum analyzers provide a smart signal generator control that assists in RF measurement setups containing a signal generator from Rohde & Schwarz. Changes in the analyzer settings are directly taken over by the generator, and the analyzer can even display the user interface of the generator so that users can operate the complete setup from one screen. SCPI recording functions of the analyzer and the generator can be coupled.

The R&S FSV3000 and R&S FSVA3000 are designed for high-speed performance in automated test systems. Both perfectly interact with cloud based processing. The optional 10 Gbit/s LAN interface enables I/Q data transfer toward the network end even at high sample rates, which is required for wideband signal analysis such as for 5G.

The R&S FSV3000 and R&S FSVA3000 are now available from Rohde & Schwarz. For more information, go to: www.rohde-schwarz.com/ad/press/fsva3000

CALIBRATED

BY TRANSCAT®

Additel

Introducing the New Additel 286 Multifunction Reference Thermometer

- ***Measure and calibrate SPRTs, RTDs, thermistors and thermocouples***
- ***1PPM resistance ratio accuracy (channel 1)***
- ***8 1/2-digit DC multimeter***
- ***Measure up to 82 channels***
- ***Sample rates up to 10 channels per second***
- ***Bluetooth, WIFI ,USB & Ethernet (RJ-45) capable***
- ***Support for creating custom control of heat sources with RS-232***
- ***Auto – zero power feature (self heating compensation)***
- ***10.1” touch screen display***
- ***Supports fully automated temperature calibrations with data collection and report generation (no software required)***

Phone: 714-998-6899
Fax: 714-998-6999
E-mail: sales@additel.com

Corporate Headquarters
2900 Saturn Street #B
Brea, CA 92821, USA

Salt Lake City Office
1364 West State Rd. Suite 101
Pleasant Grove, UT 84062, USA

www.additel.com