CAL LAB

THE INTERNATIONAL JOURNAL OF METROLOGY

Probability Distributions and Divisors for Estimating Measurement Uncertainty

PXI Interoperability: How to Achieve Multi-Vendor Interoperability in PXI Systems

Accreditation to ISO/IEC 17025: Understanding the Benefits and the Process

Training Resources for Business

2016
JANUARY
FEBRUARY
MARCH

Electric Current Measurement

DS Series Current Transducers

DANISENSE

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

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

DS200

DS2000

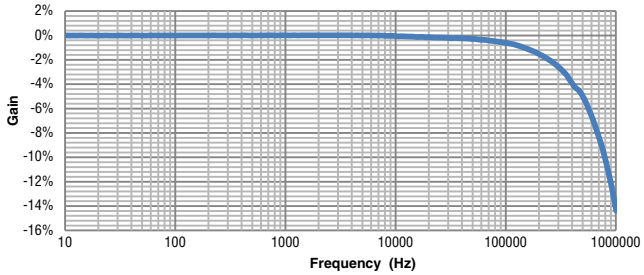
	DS200	DS600	DS2000	DS5000
Primary Current, rms	200A	600A	2000A	5000A
Primary Current, Peak	±300A	±900A	±3000A	±7000A
Turns Ratio	500:1	1500:1	1500:1	2500:1
Output Signal (rms/Peak)	0.4A/±0.6A†	0.4A/±0.6A†	1.33A/±2A†	2A/±3.2A†
Overall Accuracy	0.01%	0.01%	0.01%	
Offset	<20ppm	<10ppm	<10ppm	<5ppm
Linearity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

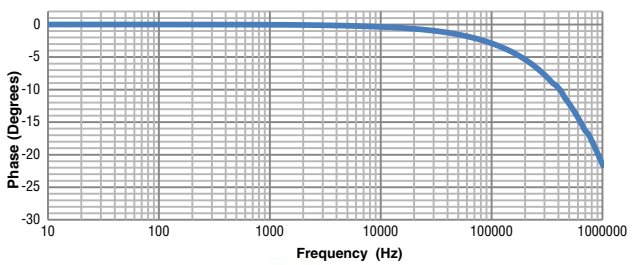
† Voltage Output options available in ±1V and ±10V

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 23, NUMBER 1

www.callabmag.com

FEATURES

DEPARTMENTS

ON THE COVER: Trescal technician calibrating a temperature captor - Trescal Morocco site.

CALENDAR

UPCOMING CONFERENCES & MEETINGS

Mar 21-23, 2016 FORUMESURE. Dakar, Senegal. Exhibition on Quality, Measurement, Accreditation and Instrumentation, FORUMESURE is an annual event, for companies and also institutions wishing to present their know-how, new products and services to hundreds of international visitors. This event is organized by The African Committee of Metrology (CAFMET). As the same time as the exhibition, the 6th International metrology Conference, CAFMET 2016, will take place. http://www.forumesure.com/.

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

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

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

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

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

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

Will Work for Training

My grandfather was born during the Great War and contracted polio by the age of 6. Being a country boy, he kept himself busy and made use out of whatever he could, including rebuilding an old, abandoned Ford. Unable to serve with his brothers in WWII, he interned with Piasecki, leading to a career at United Airlines as a mechanic. My grandmother went to a vocational school to become a nurse, and together, they built a nice life for their family… no college degree required.

While the popularity of obtaining a college education is increasing, the US work force is becoming less skilled. In response to unemployment and the need for training workers, the Workforce Innovation and Opportunity Act (WIOA) was signed in 2014 to provide businesses and workers various employment and training programs. Sustaining a skilled work force is not just vital to our industry, but to our economy as well.

The rapid modernization during the 1920s (traffic signals, refrigerators, radio) can be compared to the technology advances of the past 15 years (the internet, software applications, computer processors), where a "skills mismatch" preceded the Great Depression and the Great Recession. Not everyone believes that skills mismatch was a factor for high unemployment, but regardless, business needs to be proactive with their labor force if they want to sustain growth and innovation. A fresh momentum on the federal level, to encourage businesses to take a lead in retraining, offers valuable resources—albeit disorganized. I compiled a list of web sites on page 34 to help US businesses find resources as well as explore some training options.

For our more technical minded readers, Richard Hogan let us use his excellent primer on probability distributions for estimating measurement uncertainty. Richard has a great blog at ISOBudgets.com where he covers popular uncertainty subjects. His postings would be of interest for anyone involved in the ISO/IEC 17025 process.

And for a nice, clear overview of the ISO/IEC 17025 process, the ANSI-ASQ National Accreditation Board (ANAB) provided us with a helpful piece, "Accreditation to ISO/IEC 17025: Understanding the Benefits and the Process."

Finally, to address an increasing need for calibration labs to support PXI devices, we asked Keysight to contribute a piece called "PXI Interoperability: How to Achieve Multi-Vendor Interoperability in PXI Systems." We think it's an excellent introduction into navigating a newer technology that might be outside the typical calibration technician's comfort zone.

Happy Measuring,

Sita Schwartz

CALENDAR

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

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

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

Jun 27-28, 2016 14th IMEKO TC10 Workshop on Technical Diagnostics. Milan, Italy. "New Perspectives in Measurements, Tools and Techniques for system's reliability, maintainability and safety." The aim of the Conference is to promote a Forum where people involved with technical diagnostics, from different specialized areas, may compare their experiences and present solutions for actual and further requirements. http://www.imekotc10-2016.deib.polimi.it/

SEMINARS: Dimensional

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

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

Mar 23, 2016 The Gauge Block Handbook. Anaheim, CA. NIST Seminar – MSC. Presented by Eric Stanfield & Meghan Shilling of the NIST Physical Measurement Laboratory. One-day course on maintenance, care, use and calibration of gauge blocks for dimensional measurements. http://www.msc-conf.com/nist-seminars.html.

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

indicators height gages, etc. http://www.iictenterprisesllc.com.

Apr 7-8, 2016 Hands-On Gage Calibration and Repair. Provo, UT. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Apr 11-12, 2016 Hands-On Gage Calibration and Repair. Colorado Springs, CO. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Apr 12-14, 2016 Dimensional Measurement Training. Level 1 – Measurement User. Coventry, United Kingdom. NPL. A three day training course introducing dimensional metrology, the importance of good measurement practice and the right measurement behaviours. http://www.npl.co.uk/

Apr 18-21, 2016 Dimensional Measurement Training. Level 2 – Measurement Applier. Coventry, United Kingdom. NPL. A four day training course building on the knowledge and measurement principles gained through the Level 1 training course. http://www.npl.co.uk/

May 16-18, 2016 Dimensional Measurement Training. Level 1 – Measurement User. Coventry, United Kingdom. NPL. A three day training course introducing dimensional metrology, the importance of good measurement practice and the right measurement behaviours. http://www.npl.co.uk/

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

Jun 6-8, 2016 Dimensional Measurement Training. Level 1 – Measurement User. Coventry, United Kingdom. NPL. A three day training course introducing dimensional metrology, the importance of good measurement practice and the right measurement behaviours. http://www.npl.co.uk/

Jun 9-10, 2016 Hands-On Gage Calibration and Repair. Oklahoma, OK. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

CALENDAR

Jun 13-16, 2016 Dimensional Measurement Training. Level 2 – Measurement Applier. Coventry, United Kingdom. NPL. A four day training course building on the knowledge and measurement principles gained through the Level 1 training course. http://www.npl.co.uk/

Jun 23-24, 2016 Hands-On Gage Calibration and Repair. Bloomington, MN. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Jul 4-6, 2016 Dimensional Measurement Training. Level 1 – Measurement User. Coventry, United Kingdom. NPL. A three day training course introducing dimensional metrology, the importance of good measurement practice and the right measurement behaviours. http://www.npl.co.uk/

Jul 11-12, 2016 Hands-On Gage Calibration and Repair. Hartford, CT. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Jul 14-15, 2016 Hands-On Gage Calibration and Repair. Cleveland, OH. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

SEMINARS: Electrical

Mar 1-3, 2016 Instrumentation for Test & Measurement. Las Vegas, NV. Technology Training Inc. Course 163 presents basic information on selection, application, calibration and usage of modern measurement systems to measure electrical, environmental and dynamic phenomena. The course emphasizes a non-mathematical approach to understanding concepts and mechanisms. A variety of measurands and transducer types is covered, as well as signal conditioning, recording and analysis. http://www.ttiedu.com/

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

4010A

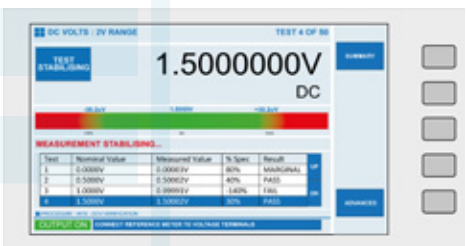
ADVANCED Multi-Product Calibrator

New Features

- VARIABLE RESISTANCE
- VARIABLE CAPACITANCE
- AC CURRENT TO 30kHz
- SCOPES TO 6GHz

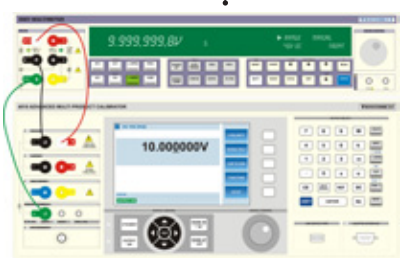
CAPABILITIES

- AC/DC Voltage to 1025V
- AC/DC Current to 30A
- 2&4 Wire Resistance to 1G
- Capacitance to 10mF
- Inductance to 10H
- Frequency to 10MHz
- RTD/PRT Simulation
- AC/DC Power Calibration
- Oscilloscope Calibration



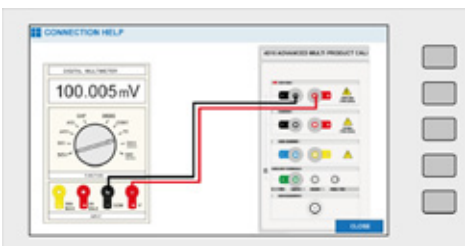
BUILT-IN CALIBRATION SOFTWARE

The 4010 incorporates user friendly software allowing the user to create, run, and store procedures without the need for a PC.



ADVANCED AUTO VALIDATION

The 4010 integrates a unique auto validation system. By connecting a precision multimeter, such as the Transmille 8081, the 4000 Series can perform a sequence of measurements for specific ranges and functions and produce a detailed report.



ADVANCED USER ASSISTANCE

Customized UUT connection diagrams or messages can also be loaded onto the system, to provide instrument specific wiring connection or calibration instructions to the user.

TRANSMILLE
Solutions In Calibration

+1(802) 846-7582
www. transmillecalibration.com

Crystal pressure

The HPC40 Series is the world's first combined pressure and mA loop calibrator to be fully temperature compensated from -20 to 50° C. You can count on the same accuracy whether measuring pressure, current, voltage, or temperature.

- 0.035% of Reading Accuracy
- Gauge, Absolute, and Differential Pressure to 15,000 psi / 1000 bar / 100 MPa
- Advanced Simplicity "Non-Menu" Interface
- Measure & Source mA with External Loop Power or Internal 24 VDC Power Supply
- High Accuracy Thermometer with "True Ohm" Technology
- Store & Recall Previously Used Screens
- Flexible Power Options Including Rechargeable

crystalengineering.net

AMETEK®
TEST & CALIBRATION INSTRUMENTS
crystalengineering.net
805.595.5477

CALENDAR

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

May 2-5, 2016 Applied Measurements for Electrical Test Instrumentation. Las Vegas, NV. Technology Training Inc. Course 164 presents basic information on selection, application, calibration and usage of modern measurement systems to measure electrical phenomena. The course emphasizes a non-mathematical approach to understanding concepts and mechanisms. A variety of measurands and device types is covered, as well as signal conditioning, recording and analysis. http://www.ttiedu.com.

SEMINARS: Flow & Pressure

Mar 23-24, 2016 Flow Measurement and Uncertainties. Anaheim, CA. NIST Seminar – MSC. Presented by Gina Kline, Aaron Johnson, & John Wright of the NIST Sensor Science Division. This 2-day seminar with cover background metrology and fluid mechanics subjects that are important for flow measurement. Flow calculations and uncertainty analyses will be taught as well as optional, advanced sections of interest to only extreme flow geeks. http://www.msc-conf.com/nist-seminars.html.

Mar 23-24, 2016 NIST Pressure and Vacuum Measurement. Anaheim, CA. NIST Seminar – MSC. Presented by Jay Hendricks and Jacob Ricker of NIST Thermodynamic Metrology Group. This 2-day course will cover fundamentals of pressure measurements. http://www.msc-conf.com/nist-seminars.html.

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

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

SEMINARS: General & Management

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

CALENDAR

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

May 23-26, 2016 Effective Cal Lab Management. Everett, WA. Fluke Calibration. Effective Cal Lab Management is ideal for anyone in a lead or supervisory position in a cal lab looking for ways to better communicate and manage personnel, and to bring about efficiency and customer satisfaction improvement. http://us.flukecal.com/training/courses/CLM-303.

SEMINARS: Industry Standards

May 2-4, 2016 Internal Auditing to ISO/IEC 17025. Covington, KY. ANAB. This course prepares an internal auditor to clearly understand technical issues relating to an audit. You'll learn how to more effectively collect audit evidence and report your findings. www.asq.org/courses/iso-iec-17025-internal-auditor.html.

Jun 6-7, 2016 Introduction to ISO/IEC 17025. Greenville, SC. ANAB. This course helps you understand and apply the requirements of the ISO/IEC 17025:2005 standard. You'll examine the origins of the standard, and learn practical concepts like document control, internal auditing, proficiency testing, traceability, measurement uncertainty, and method witnessing. http://asq.org/training/introduction-to-iso-iec-17025_INTRO17.html

Jun 6-12, 2016 ISO/IEC 17025 Lead Assessor Training. Greenville, SC. ANAB. Want to learn better audit practices using the ISO/IEC 17025 standard? This course will prepare you to meet technical demands of the standard while providing practical exercises to aid comprehension. http://www.asq.org/courses/iso-iec-17025-lead-assessor.html.

SEMINARS: Mass & Weight

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

CALENDAR

SEMINARS: Measurement Uncertainty

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

Mar 23-25, 2016 Hands-on Workshop on Assessing and Reporting Measurement Uncertainty. Anaheim, CA. NIST Seminar – MSC. Presented by Hung-Kung Liu & William Guthrie of the NIST Statistical Engineering Division. This short, 3-day course covers the propogation of measurement uncertainty using the methods outlined in the JCGM from a statistical perspective. http://www.msc-conf.com/nist-seminars.html.

May 3-5, 2016 Introduction to Measurement Uncertainty. Everett, WA. Fluke Calibration. MET-302 Hands-On Metrology Statistics is a three-day course that will teach you how to develop uncertainty budgets and to understand the necessary calibration processes and techniques to obtain repeatable results. http://us.flukecal.com/training/courses/MET-302.

May 5-6, 2016 Fundamentals of Measurement Uncertainty. Covington, KY. ANAB. Learn a practical approach to measurement uncertainty (MU) applications, based on fundamental practices. Hear about MU for both testing and calibration laboratories and understand the steps required, accepted practices, and the types of uncertainties that need to be considered by an accredited laboratory. http://asq.org/training/fundamentals-of-measurement-uncertainty_FMU.html.

Jun 14-15, 2016 Measurement Uncertainty (per ILAC P14 Guidelines). Boston, MA. WorkPlace Training. This workshop introduces basic measurement uncertainty and traceability concepts. The concepts taught are then put in practice by developing sample measurement uncertainty budgets. http://www.wptraining.com.

SEMINARS: Software

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

Jun 20-24, 2016 Basic MET/CAL® Procedure Writing. Everett, WA. Fluke Calibration. In this five-day basic MET/CAL procedure writing course, you will learn to configure MET/CAL software to create, edit, and maintain calibration solutions, projects and procedures. http://us.flukecal.com/software-training.

Aug 22-26, 2016 Basic MET/CAL® Procedure Writing. Everett, WA. Fluke Calibration. In this five-day basic MET/CAL procedure writing course, you will learn to configure MET/CAL software to create, edit, and maintain calibration solutions, projects and procedures. http://us.flukecal.com/software-training.

CALENDAR

SEMINARS: Temperature

Mar 23, 2016 Cold Chain. Anaheim, CA. NIST Seminar – MSC. Presented by Michal Chojnacky of the NIST Sensor Science Division, Thermodynamic Metrology Group. In this one-day seminar, participants will learn effective temperature monitoring strategies for use in cold-chain transport and storage of temperature-sensitive products. http://msc-conf.com/nist-seminars.html.

Mar 23-24, 2016 Selection, Calibration, and Use of Contact Thermometers. Anaheim, CA. NIST Seminar – MSC. Presented by Dawn Cross & Karen Garrity of the NIST Sensor Science Division, Thermodynamic Metrology Group. In this 2-day seminar, we will discuss contact thermometers commonly used in industry for application that use platinum resistance thermometers, thermistors and thermocouples. http://msc-conf.com/nist-seminars.html.

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

May 17-19, 2016 Infrared Calibration Training. American Fork, UT. Fluke Calibration. A three-day course with plenty of hands on experience in infrared temperature metrology. Topics covered include emissivity, size of source effect, reflected temperature, spot size, calibration schemes, calibration sources, alignment, uncertainty analysis, and IR thermometry usage. http://us.flukecal.com/tempcal_training.

SEMINARS: Vibration

Mar 7-9, 2016 Fundamentals of Vibration for Test Applications. Las Vegas, NV. Technology Training Inc. Course 116 covers a wide range of topics associated with vibration and shock applications in order to enable the course participants to acquire a basic understanding of the complex field of vibration and shock. http://www.ttiedu.com.

Visit **www.callabmag.com** for upcoming metrology webinars!

Danaher Announces New Company

Dec. 3, 2015 /PRNewswire/ — Danaher Corporation (NYSE: DHR) (the "Company") revealed the name of the new diversified industrial growth company expected to launch in 2016 as Fortive Corporation. Fortive will be comprised of two segments, Professional Instrumentation and Industrial Technologies, and will include market leading brands such as Fluke, Qualitrol, Tektronix, Gilbarco Veeder-Root, Kollmorgen and Matco Tools.

James A. Lico, current Danaher Executive Vice President and future President and Chief Executive Officer of Fortive, stated, "Fortive takes its name from the Latin root 'fort' meaning strong. Combined with a mark symbolizing forward momentum, growth and progress, the Fortive brand reflects the strength of our company—a company built on a foundation of success, and geared for growth and outperformance. As a standalone company, we will pursue a strategy focused on creating value through organic growth, operating margin expansion, and mergers and acquisitions. Our approach to acquisitions will be strategic and financially-disciplined, with the goal of building even stronger businesses with competitive leadership positions."

"The Fortive Business System will be the core of our operating model, the cornerstone of our culture and our competitive advantage. Our outstanding team has a strong Danaher legacy and will continue to operate with the rigor and agility necessary to make continuous improvement a part of everything we do," said Lico.

The Company will file a Form 10 Information Statement with the U.S. Securities and Exchange Commission later today. Once filed, a copy of the form will be made available on the Investors page of www.danaher.com.

Fortive intends to apply to list its common stock on the New York Stock Exchange. The Company now expects the spin-off transaction to be completed in the third quarter of 2016.

Fortive will be headquartered in Everett, Washington, and will employ more than 20,000 people worldwide. Fortive's revenues for the year ended December 31, 2014 were $6.3 billion. Fortive will have market leading positions in such areas as professional instrumentation, automation, sensing and transportation technologies. The company's website is www.fortive.com.

World Recognition of Measurements INM

11/06/2015 - Colombia has been notified by the Bureau International des Poids et Mesures - BIPM, the publication of thirty-seven (37) Calibration and Measurement Capabilities - CMC on the basis of key data comparison - KCDB.

This step will mark a milestone demonstrating the country and at the international level, which measures temperature and humidity correctly in supporting the achievement of the Free Trade Agreement (FTA) and contributing to improving the quality of life of all people.

This contributes to the removal of technical barriers to trade, and recognition of the activities of all exporters, accredited laboratories and products that are related to the published calibration capabilities. These capabilities are in the ranges of -80 ° C to 1200 ° C, also in relative humidity (RH) 12% RH and 85% RH.

What is it good for?

Temperature is the most measured magnitude globally, so it is one of the most important parameters for measuring and control in science, technology and industry; for example, in producing the supporting structures of modern life as concrete and asphalt, in the production of glass, semiconductors, petrochemicals, plastics and pharmaceuticals. Temperature is also important in the production, handling, transport and custody of fruits and foods using the maintenance of the cold chain.

Cell water triple point, national measurement standard in Colombia.

Also the temperature is essential in measuring clinical parameters that determine the health of a person, weather, preparation, preservation and transport of food, biological samples, plant crops and aquatic species staple food, in air conditioning systems, gas liquefaction and cooling of superconducting magnets of medical imaging scanner.

Temperature and humidity are two physical quantities that are intimately present in life itself, natural phenomena and therefore in the daily lives of people. A simple description of them is as follows: the temperature is a measure of the kinetic energy of a system and the humidity is a measure of the vapor content in the air, (we speak here of humidity), or more generally content Water also in a system. The word system makes relation to an object of study and is typical of thermodynamics. While temperature is a fundamental quantity, humidity is a derived quantity of the International System of Units.

In each of the elements mentioned above, among others, it presents the Metrology rationale of the National Institute of Metrology-INM in support of Trade, industry and the quality of life of Colombians.

This was the way.

To reach this point, the laboratory temperature and humidity of Colombia INM went through the process of review and approval of thirty-seven (37) Calibration and Measurement Capabilities, which were subjected by Regional Metrology Organizations (RMO - Regional Metrology Organizations). The RMO who conducted the review process on this occasion were the SIM of America, EURAMET in Europe, Africa AFRIMETS, APMP Asia and the Pacific, Asia and Europe COOMET.

Along with this process (in September 2015), the Inter-American Metrology System, SIM recognizes the National Institute of Metrology, INM as one of the evaluators of interlaboratory comparisons in the field of thermometers thermocouple recognition connected to physical Ciro Alberto Sanchez Morales Laboratory temperature and humidity of the Division of Physical Metrology INM in his capacity as expert on the subject.

Let history.

The Meter Convention signed on May 20, 1875, it is an international treaty that established three organizations to address regarding the preservation of metric standards. It was reviewed at the Sixth General Conference of Weights and Measures (CIPM) in 1921. In 1960 the unit system set was renamed "International System of Units" (abbreviated SI, French Système international d'unités, English International System of Units). Colombia is part of the BIPM, as a full member since February 6, 2013.

The International Bureau of Weights and Measures (BIPM, by its French acronym) is the entity that coordinates international metrology world. Its mission is to ensure and promote the global comparability of measurement results aligned to the International System of Units (SI). One of the activities of the BIPM is to manage the process of international review of the CMC offered by a laboratory in a specific size; CMC declared once approved, then the BIPM CMC publishes these on its website KCDB (Key Comparison Database). Colombia signed on 15 May 2013 accession to the MRA (CIPM-MRA for its acronym in English)

Find more detailed publications:

http://kcdb.bipm.org/appendixC/country_list_search.asp?page=1&pge=1&CountSelected=CO&type=T

References: Rusby, R. "Beginner´s Guide to Temperature Measurement." Measurement Good Practice Guide No. 125. NPL. 2012.

NIST Performs Critical Measurements for James Webb Space Telescope

The National Institute of Standards and Technology (NIST) has accurately measured parts designed for the upcoming James Webb Space Telescope, the long-awaited successor to the Hubble Space Telescope. The NIST-measured composite titanium and stainless steel parts, which support the skeleton for the telescope's massive mirror, will be used in the final round of NASA's vibration tests on the mirror assembly before the telescope's scheduled launch in October 2018.

The Webb telescope will travel to an orbit beyond the Moon, contain a mirror much larger than the Hubble's, and be able to observe the formation of some of the first stars and galaxies more than 13.5 billion years ago. The telescope is the largest piece of precision metrology (measurement) equipment that NASA has been involved in creating. With its size, and the sophistication of its parts, extreme care must be taken to ensure the mirror and instruments remain properly assembled and aligned as they travel into space and face significant temperature changes throughout their journey.

"When you have something like this and bring it into orbit, you can't go up to space and reposition it" if something goes out of position or alignment, said John Stoup, a mechanical engineer at NIST's Physical Measurement Laboratory in Gaithersburg, Md.

Stoup and his colleagues performed measurements of four alignment mounts that support and help to position a major Webb telescope structure known as the Primary Mirror Backplane Support Structure (PMBSS). The structure will hold the telescope's big 6.5-meter (21-foot) diameter mirror as well as approximately 2,400 kilograms (5,300 pounds) of the telescope's instruments and optical components.

NIST's M48 Coordinate Measurement Machine (CMM) measured the four mounts, which are 200 millimeters (7.87 inches) on a side and 150 millimeters (5.91 inches) high. The most accurate machine in the world for measuring parts on this relatively large size scale, the M48 CMM uses laser interferometry to measure the location of a ruby tip that is placed in contact with the components being measured. The room in which the measurements were done has a stable thermal environment that can be controlled to a few thousandths of a degree. The mounts were accurately

measured to within 5 micrometers, the tolerance that NASA needed for these parts.

"The precision of the backplane assembly has to be impeccable for the high-quality work they want to do with the telescope," Stoup said.

Workers at the NASA Goddard Space Flight Center, located in Greenbelt, Md., needed these measurements done very quickly for upcoming tests, with a one-week turnaround.

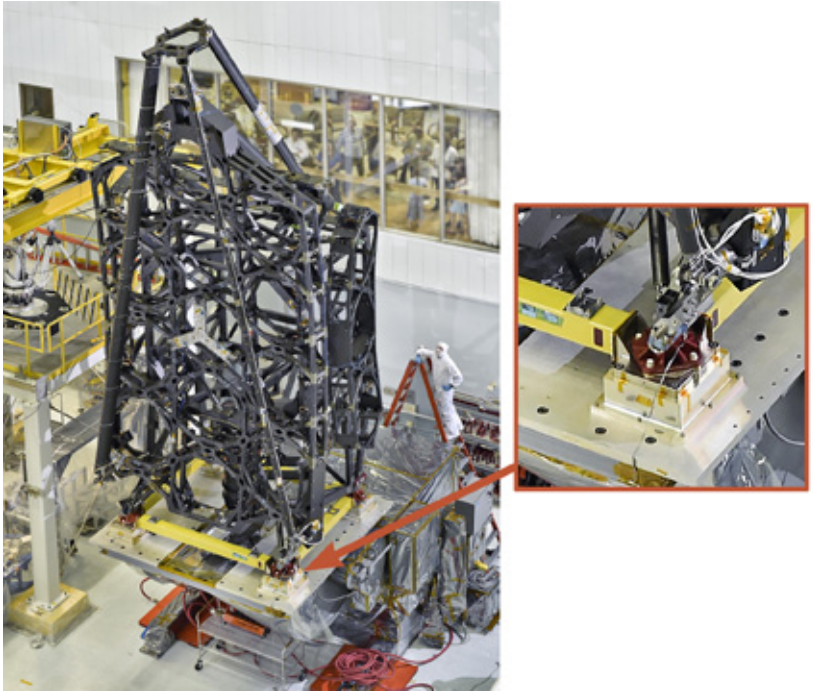
"They know we're down the road," said Stoup. "The same day they called about the parts, they drove them down here," and he and his colleagues started work on the measurements that afternoon, he said.

With the measurements, the NASA researchers have the information they need to position and orient the parts and the components within them during their upcoming vibration tests, which are an important step in determining that the telescope will operate properly in space. The ultimate goal is to identify and minimize the actual stresses the mirrors will experience during launch and orbit. Vibration tests are such an important component of space-worthiness testing that they even provided a major plot point in the book and movie The Martian. In the story, skipping the tests led to a failed probe launch.

This was the third set of measurements that NIST has performed for the Webb telescope. Stoup said he has been proud to play a part in the Webb project.

"There are so many pieces that go into it, and when you look at everything that needs to be done, you really see how impressive this telescope is. It's an amazing project," he said.

Source: NIST Physical Measurement Laboratory, Engineering Physics Division, February 2, 2016 (http://nist.gov/pml/div683/nist-performs-critical-measurements-for-james-webb-space-telescope.cfm).



The complete Primary Mirror Backplane Support Structure (PMBSS) for the James Webb Space Telescope (JWST). The inset shows the location of the four support mounts of the type that NIST measured. For scale, note the assembly technician in the photo. The PMBSS is the largest single structure on the JWST and also the largest precision metrology structure that has ever been built for a NASA program.
Credit: NASA

New Twist to NIST Antenna Measurements and Calibrations

November 30, 2015 - The National Institute of Standards and Technology (NIST) has been pioneering antenna measurement methods for decades, but a new robot may be the ultimate innovation, extending measurements to higher frequencies while characterizing antennas faster and more easily than previous NIST facilities.

The robot—actually a robotic arm of the type used in manufacturing—will be used to rapidly and accurately measure the properties of antennas used in advanced communications, remote sensing for weather prediction and climate monitoring, imaging systems and radar.

NIST researchers came up with the idea for the robotic arm in 2011 as a means of meeting the demands posed by new, high-frequency antennas. The robot has now been validated and is being used to serve NIST customers. Officially introduced in a new paper,* the robot's formal name is the Configurable Robotic Millimeter-Wave Antenna (CROMMA) facility.

"We designed this system to address a need in the antenna community for high-precision and configurable scanning at short, millimeter wavelengths," lead researcher Joshua Gordon says. "Past systems haven't been as complete as they need to be. The robot allows us to explore many ways of doing measurements. There's a lot of configurability and an extremely high level of repeatability."

Robotics is the latest advance in the widely used near-field scanning technique, pioneered by NIST in the 1970s.** The method uses complex mathematical models to determine antenna properties and calculate performance at long distances—where it counts—using data collected indoors close to the antenna, where it's easier to get accurate readings. Near-field scanning allows researchers to assess an antenna's gain (signal power transmitted or received), polarization (orientation of the electromagnetic field) and pattern (angular distribution of transmitted or received energy).

TRANSCAT®

Trust in every measure

Renting Fluke 5522A Calibration Lab Standards

with Accredited Calibration Certificates

Is your Fluke calibrator in for its scheduled calibration or an unscheduled repair?

Reserve your rental now!

Do you need another asset to keep up with the volume?

Get a spare unit in days to help process your work.

Do you need an accredited cert with uncertainties to be fully operational?

Transcat is the only rental provider of lab standards who is also fully accredited by NVLAP to calibrate them.

Do you need a long-term rental or a lease?

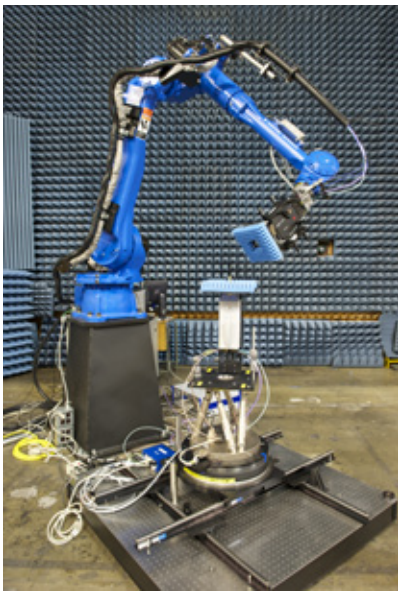
Ask us about our flexible options!

Keep Your Lab Running —
Rent a Fluke Calibration Standard from Transcat

TRANSCAT®.com/rental

800-828-1470

***Mention this AD and get 40% off your 5522A Rental!**



NIST's latest antenna range relies on a robot to measure virtually any property of any antenna for applications such as advanced communications. Credit: Suplee/NIST

The six-axis robot can twist into unusual positions to measure the properties of a test antenna up to 2 meters (6.6 feet) in diameter positioned on a hexapod stage. A laser tracker monitors and records positions used for fine correction of robot postures to ensure the necessary precision. It's like a high-tech form of the game Twister.

Antennas can be dynamically positioned with a precision of tens of micrometers in all six degrees of freedom—up or down, left or right, forward or back, tilting, turning and rolling. The arm can hold up to 35 kilograms (70 pounds) and can measure antenna properties in almost any user-definable pattern, including the three popular paths: spherical, planar and cylindrical. No longer is a separate antenna measurement setup needed for each path type.

At first, the robot will measure frequencies from 100 gigahertz (GHz) to 300 GHz with the goal of eventually reaching 500 GHz and higher. High frequencies—with very short wavelengths of radiation—are used in many current and emerging applications due to improved spatial resolution, smaller antenna

components and higher data rates. There is a particular need for accurate antenna pattern measurements above 100 GHz, a range that holds promise for future generations of advanced communications antennas and improved weather and climate prediction.

NIST calibrates antennas for a variety of industrial and military customers, offers a bi-annual course to transfer near-field technology to industry and other users, and also helps other organizations establish their own antenna measurement facilities. NIST's robotic antenna measurement technology is being transferred to industry.

* J.A. Gordon, D.R. Novotny, M.H. Francis, R.C. Wittmann, M.L. Butler, A.E. Curtin and J.R. Guerrieri. 2015. Millimeter-Wave Near-Field Measurements Using Coordinated Robotics. *IEEE Transactions on Antennas and Propagation.* Vol. 63, Issue 12. Posted online Nov. 25. DOI: 10.1109/TAP.2015.2496110

** The research leading to the near-field technique started in the 1950s, and the theory was published in 1960. After NIST demonstrated successful measurements of many types of antennas, including those on satellite communications dishes, radar systems and planetary probes in deep space, the technique was widely accepted. Today, there are about 1,000 ranges making near-field measurements throughout the world. The method saves space, time and money.

Source: NIST Communications Technology Laboratory, RF Technology Division, November 30, 2015, http://nist.gov/ctl/rf-technology/robot-adds-new-twist-to-nist-antenna-measurements-and-calibrations.cfm.

Nature Physics Launches New Column Dedicated to Measurement

Starting this January, *Nature Physics* draws attention to metrology with a new dedicated monthly column: Measure for Measure. Michael de Podesta, temperature scientist at the National Physical Laboratory (NPL), kicks off the series with a reflection on the kelvin.

The short one-page essays, covering physical units, fundamental constants or anything else measurement-related, are designed to be informative, yet accessible to the non-specialist. By making the series freely available, *Nature Physics* is hoping to reach audiences outside its core readership.

An editorial introducing the new column highlights the crucial yet often overlooked role metrology has to play in science. Physics is all about observations, quantified through measurements, expressed in units. National measurement institutes, such as NPL, are responsible for defining and curating this system of units, and their research continues to move fundamental physics forward and spark new technologies.

In the inaugural article, "Rethinking the Kelvin," Michael de Podesta discusses the definition of the base unit of temperature and why we're planning to change it. Under the current system, all temperature measurements are indirect comparisons against a fixed point: the triple point of water. Rather than choosing an arbitrary temperature as an exact standard, the planned 2018 redefinition will instead state an exact value of the Boltzmann constant, which is a measure of the relationship between the kinetic energy of molecules and temperature.

The kelvin will then be defined in terms of fundamental physical constants. This won't make measuring temperature any easier, but it will lift the limits on potential future improvements in measurement techniques. "If we had collectively understood what temperature was when we learned to measure it, then we would have defined the unit of temperature in this way in the first place," Michael explains.

The redefinition of the kelvin, alongside the other SI base units, could have far-reaching benefits. As the *Nature Physics* editorial concludes: "It's clear that progress in metrology and advances in science go hand in hand. [Dutch physicist and Nobel laureate] Heike Kamerlingh Onnes's laboratory motto captures it nicely: *door meten tot weten* - through measuring to knowing."

Source: National Physical Laboratory (NPL) News, January 25, 2016 (http://www.npl.co.uk/news/nature-physics-launches-new-column-dedicated-to-measurement).

NIST SEMINARS

N01 – Selection, Calibration, and Use of Contact Thermometers
Wednesday+Thursday, March 23-24 | 2 Full Days

N02 – Cold Chain
Wednesday, March 23 | Full Day

N03 – Hands-on Workshop on Assessing and Reporting Measurement Uncertainty
Wednesday+Thursday+Friday, March 23-25 | 3 Full Days

N04 – Flow Measurement and Uncertainties
Wednesday+Thursday, March 23-24 | 2 Full Days

N05 – The Gauge Block Handbook
Wednesday, March 23 | Full Day

N06 – NIST Pressure and Vacuum Measurement
Wednesday+Thursday, March 23-24 | 2 Full Days

WWW.MSC-CONF.COM/NIST-SEMINARS.HTML

TUTORIAL WORKSHOPS

T02 – Liquid Flow Rig Measurement Uncertainty Assessment
Wednesday, March 23 | Full Day

T03 – Weighing Practices: A Risk-Based approach to Selection, Calibration and Testing of Weighing Instruments
Wednesday, March 23 | Full Day

T04 – Metrology 101 – Back to Basics
Wednesday, March 23 | Full Day

T05 – Healthcare Metrology Program Documentation: Best Practices – An Industry Perspective
Wednesday, March 23 | Full Day

T06 – Particle Monitoring Systems for Pharmaceutical Manufacturing Guidance
Thursday, March 24 | Half Day AM

T07- Coriolis Meter Measurement Uncertainty Analysis
Thursday, March 24 | Half Day AM

T08 – From Kelvin to Fever Temperature Measurements
Thursday, March 24 | Half Day AM

T09 – Pressure-Flow BI-Lok Fittings Metrology
Thursday, March 24 | Half Day AM

T10- Advanced Flowmeter Diagnostic Capabilities
Thursday, March 24 | Half Day PM

T11 – Qualification of Analytical Spectrophotometers
Thursday, March 24 | Half Day PM

T12 – Pressure Metrology: Basics of Pressure Behavior, Measurement, and Calibration
Thursday, March 24 | Half Day PM

T13 – Did You Really Mean to Write That? Technical Writing from a Metrology Perspective
Thursday, March 24 | Half Day PM

T14 – Measurement and Quality: A Strategic and Financial Advantage
Thursday, March 24 | Half Day PM

T15 – Introduction to Automated Calibration Using MS® VB.NET, C# and Metrology.NET™
Thursday, March 24 | Half Day PM

WWW.MSC-CONF.COM/TUTORIAL-WORKSHOPS.HTML

TECHNICAL SESSIONS

These 75- Minute sessions are meant to present real applications, real results, and real solutions based on Metrology and Quality principles or theory – **Thursday & Friday, March 24-25.**

Track A: Emerging Technologies (7 Sessions)
Track B: Laboratory & Calibration (7 Sessions)
Track C: BioScience, Pharmaceutical & Healthcare (7 Sessions)
Track D: Petrochemical (4 Sessions) & Environmental (3 Sessions)
Track E: Quality & Process Management (7 Sessions)

WWW.MSC-CONF.COM/TECHNICAL-SESSIONS.HTML

DISNEYLAND HOTEL

The MSC is again proud to offer specially priced room rates $189, a substantial reduction off Disneyland's regular room rates. The room rates are available for your visit 3 days before and 3 days after the conference.

Please visit http://www.mydisneymeetings.com/gdmc16a/ or call (714) 520-5005 M-F from 8am to 5pm (PST) for group reservations.

2016

"Broadening our Horizons in Metrology, Calibration & Quality Processes"

46th Annual

MEASUREMENT SCIENCE CONFERENCE

REGISTER AT
WWW.MSC-CONF.COM

For over 45 years, MSC has provided thousands of Technicians, Engineers, and Managers with an unparalleled immersion-based learning experience which equips, enables, and empowers them to achieve true competitive advantage and to propel their organizations in transformational ways. For this reason, MSC is recognized as the premier provider of education and training to professionals in the Testing, Calibration, and Precision Measurement Science fields.

We invite you to join us this coming March 23rd, 24th, and 25th in Anaheim, CA.

MARCH 23rd - 25th, 2016

AT THE DISNEYLAND HOTEL IN ANAHEIM, CA

1.866.672.6327 | www.msc-conf.com

Probability Distributions and Divisors for Estimating Measurement Uncertainty

Richard Hogan
ISOBudgets LLC

Introduction

Probability distributions are a part of measurement uncertainty analysis that people continually struggle with. Today, my goal is to help you learn more about probability distributions without having to grab a statistics textbook. Although there are hundreds of probability distributions that you could use, I am going to focus on the 6 that you need to know.

If you constantly struggle with probability distributions, keep reading. I am going to explain what probability distributions are, why they are important, and how they can help you when estimating measurement uncertainty.

What is a Probability Distribution?

Simply explained, probability distributions are a function, table, or equation that shows the relationship between the outcome of an event and its frequency of occurrence.

Probability distributions are helpful because they can be used as a graphical representation of your measurement functions and how they behave. When you know how your measurement functions have performed in the past, you can more appropriately analyze it and predict future outcomes.

Before jumping head-first into the different types of probability distribution, let's first learn a little more about probability distributions. In the next few paragraphs, I am going to explain some characteristics that you should know.

Skewness

Skewness is a measure of the probability distributions symmetry. Look at the chart below to visually understand how probability distributions can skew to the left or the right.

Histogram

A histogram is a graphical representation used to understand how numerical data is distributed. Take a look below at the histogram of a Gaussian distribution.

Look at the histogram and view how the majority of the data collected is grouped at the center. This is called central tendency.

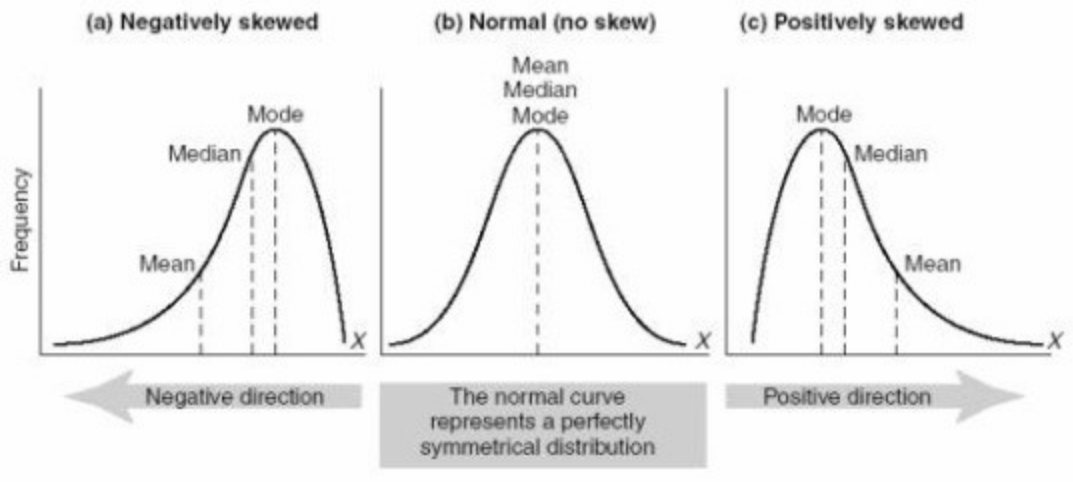


Figure 1. Skewness

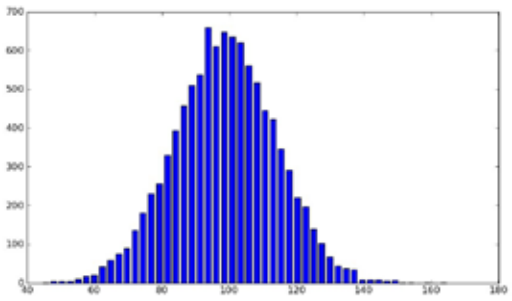


Figure 2. Histogram

Now look at the height of each bar in the histogram. The height of the bars indicate how frequent the outcome it represents occurs. The taller the bar, the more frequent the occurrence.

Kurtosis

Kurtosis is a measure of the tailedness and peakedness relative to a normal distribution. As you can see from the image below, distributions with wider tails have smaller peaks while distributions with greater peaks have narrower tails. Do you see the relationship?

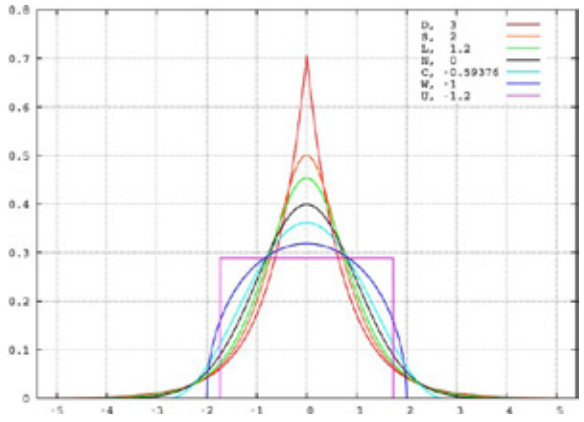


Figure 3. Kurtosis

Why Is It Important?

I know it seems like I am making you read more information than you want to know, but it is important to know these details so you can select the appropriate probability distribution that characterizes your data.

If you are uncertain how your data is distributed, create a histogram and compare it to the following probability distributions.

Most Commonly Used Probability Distributions

The most commonly used probability distributions for estimating measurement uncertainty are:

- Normal
- Rectangular
- U-Shaped
- Triangle
- Log-Normal
- Rayleigh

Below you will find a list of the most common probability distributions used in uncertainty analysis. After reading this article, you should be able identify which probability distributions you should use and how to reduce your uncertainty contributors to standard deviation equivalents.

Gaussian (a.k.a. Normal) Distribution

The Normal distribution is a function that represents the distribution of many random variables as a symmetrical bell-shaped graph where the peak is centered about the mean and is symmetrically distributed in accordance with the standard deviation.

The normal distribution is the most commonly used probability distribution for evaluating Type A data. If you do not know what Type A data is, it is the data that you collect from experimental testing, such as repeatability, reproducibility, and stability testing.

To get a better understanding, imagine you are going to collect 100 measurement samples and create a histogram graph with your results. The histogram for your data should resemble a shape close to a normal distribution.

The more data you collect, the closer your histogram will begin to resemble a normal distribution.

Now, I do not expect you to collect 100 samples every time you perform a repeatability and reproducibility test. Instead, I recommend that you begin by collecting 20 to 30 samples for each test. This should give you a good baseline

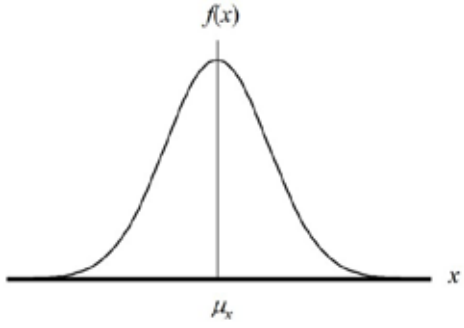


Figure 4. Normal Distribution

to begin with and allow you to characterize your data with a normal distribution.

To reduce normally distributed data to a standard deviation equivalent, use the following equation. The variable a will be the value of your uncertainty contributor and k is the value of your expansion factor.

$$u_i = \frac{U_i}{k}$$

For example, if you collect 20 samples for a repeatability experiment and calculate the standard deviation, the value of k is 1. If you are wondering, it is equal to 1 because your standard deviation is already at the 1-sigma level (i.e. 68.27% confidence). So, if your calculated standard deviation is 1 ppm, then

$$u_i = \frac{U_i}{k} = \frac{1}{1} = 1.000.$$

When using Microsoft Excel to calculate measurement uncertainty, use the following equation:

=[Cell1]/1.

For the next example, imagine you are evaluating the measurement uncertainty from your calibration report. Most likely, it is reported to 95% confidence where k equals 2 (I am sure that you have read this somewhere before). If your reported uncertainty is 1 ppm, then

$$u_i = \frac{U_i}{k} = \frac{1}{2} = 0.500.$$

When using Microsoft Excel to calculate measurement uncertainty, use the following equation:

=[Cell1]/2.

Rectangular (a.k.a. Uniform) Distribution

The Rectangular Distribution is a function that represents a continuous uniform distribution and constant probability. In a rectangular distribution, all outcomes are equally likely to occur.

The rectangular distribution is the most commonly used probability distribution in uncertainty analysis. If you are wondering why, it is because it covers the majority of uncertainty factors where the evaluator says, "I am not sure how the data is distributed."

When you are not confident how your data is distributed, it is best evaluate it conservatively. In this situation, the rectangular distribution is a great default option which is why most ISO/IEC 17025 assessors recommend it. So, make sure to pay attention; you will be using this probability distribution a lot.

To reduce your uncertainty contributors to standard deviation equivalents, you will want to divide your values by the square-root or 3.

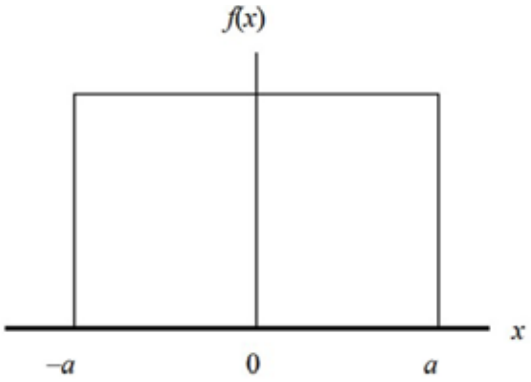


Figure 5. Rectangular Distribution

$$u_i = \frac{U_i}{\sqrt{3}}$$

For example, if you performing measurement uncertainty analysis and evaluating the contribution of a factor that has an influence of 1 part-per-million and you propose that the data is uniformly distributed, then

$$u_i = \frac{U_i}{\sqrt{3}} = \frac{1}{\sqrt{3}} = 0.577350 \approx 0.577.$$

When using Microsoft Excel to calculate measurement uncertainty, use the following equation:

=[Cell1]/SQRT(3).

U-Shaped Distribution

The U-shaped distribution is a function that represents outcomes that are most likely to occur at the extremes of the range. The distribution forms the shape of the letter 'U,' but does not necessarily have to be symmetrical.

The U-shaped distribution is helpful where events frequently occur at the extremes of the range. Consider the thermostat that controls the temperature of your laboratory. If you are not using a Proportional-Integral-Derivative (PID) controller, your thermostat controller only attempts to control temperature by activating at the extremes.

For example, imagine that your laboratory thermostat is set at 20 °C and controls temperature to 1 °C. Most likely, your thermostat does not activate your HVAC system until the laboratory temperature reaches either 19 °C or 21 °C. This means that your laboratory is not normally at 20 °C. Instead, your laboratory temperatures are floating around the limits of the thermostat's thresholds before activating or deactivating.

For this reason, it is best to characterize your laboratory temperature data using a U-shaped distribution.

To reduce your uncertainty contributors to standard deviation equivalents, you will want to divide your values by the square-root or 2.

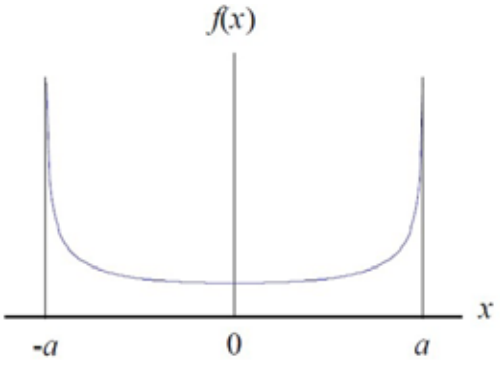


Figure 6. U-Shaped Distribution

$$u_i = \frac{U_i}{\sqrt{2}}$$

So, if you performing measurement uncertainty analysis and evaluating the contribution of a factor that has an influence of 1 part-per-million and you propose that the data for this factor is U-shaped distributed, then

$$u_i = \frac{U_i}{\sqrt{2}} = \frac{1}{\sqrt{2}} = 0.707107 \approx 0.707.$$

When using Microsoft Excel to calculate measurement uncertainty, use the following equation:

=[Cell1]/SQRT(2).

Triangle Distribution

The Triangle Distribution is a function that represents a known minimum, maximum, and estimated central value. It is commonly referred to as the "lack of knowledge" distribution because it is typically used where a relationship between variables is known, but data is scare.

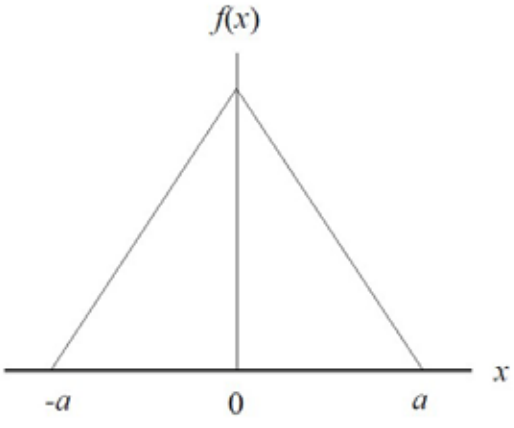


Figure 7. Triangle Distribution

Additionally, the triangle distribution is commonly used where the data collection is difficult or expensive.

For a real world example, image your laboratory is temperature controlled using a PID thermostat controller. The PID thermostat controller is constantly trying to achieve the target temperature set-point. For this reason, the temperatures in your laboratory are constantly floating around 20 °C and rarely reach the temperature thresholds (i.e. limits) of a typical thermostat controller.

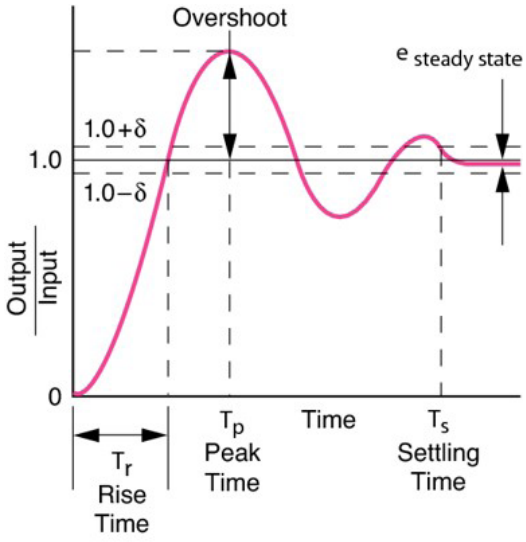


Figure 8. PID Thermostat Controller

What this means is that most of your laboratory's temperature data is centered around your set temperature. Therefore, it is best characterized by a triangular distribution because we know the limits and the estimated mean but we are unsure how the data is distributed between these points.

To reduce your uncertainty contributors to standard deviation equivalents, you will want to divide your values by the square-root or 6.

$$u_i = \frac{U_i}{\sqrt{6}}$$

So, if you are performing measurement uncertainty analysis and evaluating the contribution of a factor that has an influence of 1 part-per-million and you propose that the data for this factor is triangle distributed, you would reduce its value by using the equation above.

$$u_i = \frac{U_i}{\sqrt{6}} = \frac{1}{\sqrt{6}} = 0.408248 \approx 0.408$$

If you using Microsoft Excel to calculate measurement uncertainty, use the following equation:

=[Cell1]/SQRT(6).

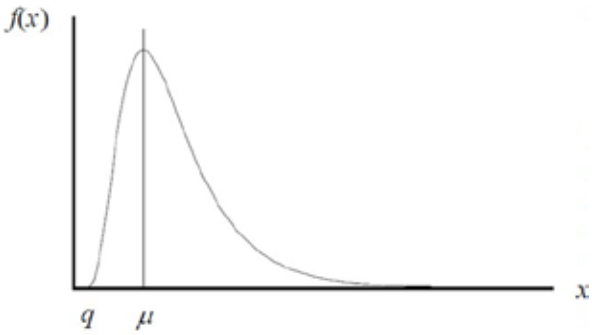


Figure 9. Log-Normal Distribution

Log-Normal Distribution

The log-normal distribution is a function of a natural logarithm that is normally distributed.

The log-normal distribution is a distribution commonly encountered but rarely used. Most of the time it is the result of lack of knowledge or failure to develop a histogram for your data.

For example, if you are performing measurements that are finite, such as length, height, weight, etc., you are most likely going to end up with data that resembles a log-normal distribution. It is most common in dimensional and mechanical metrology.

To give a better understanding, think of calibrating a gage block. Before you begin calibration, you know the target length. If you perform repeated measurements at the single point on the gage block, the majority of your measurement results will be centered around the actual length of the gage block. Some measurement results will be larger than the actual value of the gage block, and much fewer measurement results will be less than the actual value of the gage block.

The reason this happens is your measurement results are limited by the length of the gage block. Realistically, you cannot measure less than the length of the block, so your measurement results are finite or limited.

Make sure to consider the log-normal distribution next time you are performing measurements that are finite. It may prevent you from encountering measurement errors and miscalculated uncertainties.

To reduce your uncertainty contributors to standard deviation equivalents, you will want use the following equation

$$u_i = (m - q)e^{\frac{\lambda^2}{2}}\sqrt{e^{\lambda^2} - 1}$$

where, m = median and q = limit.

Rayleigh Distribution

Rayleigh distributions are used when the magnitude of a vector is associated with its directional components (e.g. x and y), which can also be real and imaginary components.

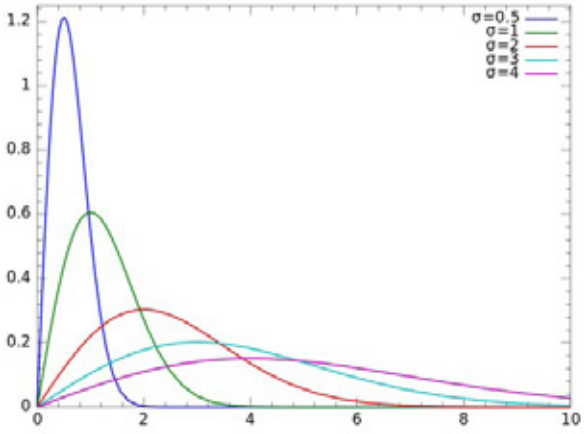


Figure 10. Rayleigh Distribution

When directional components are orthogonal and normally distributed, the resulting vector will be Rayleigh distributed.

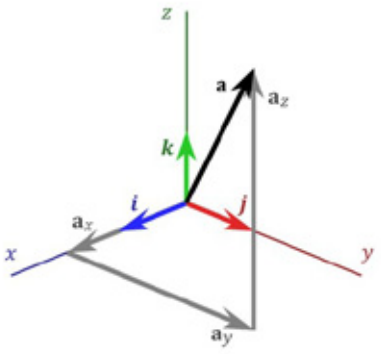


Figure 11. Vectors

Rayleigh distributions are commonly used in electrical metrology for RF and Microwave functions. Additionally, they are commonly used in mechanical metrology where vectors are involved.

For example, when wind velocity is analyzed by its 2 dimensional vector components, x and y, the resulting vector is Rayleigh distributed. For this to happen, x and y must be orthogonal and normally distributed.

Reducing uncertainty components to standard deviation equivalents is tricky with the Rayleigh distributions. You will need to know the standard deviation of each directional component to calculate the measurement uncertainty of the vector component. Afterward, you can use the equation below to reduce your uncertainty component to a standard deviation equivalent.

$$u = \frac{U_i}{\sqrt{2 \bullet In(20)}}$$

For a better explanation, read "Revisiting Mismatch Uncertainty with the Rayleigh Distribution," by Michael Dobbert of Keysight Technologies.

Conclusion

Probability distributions are an important part of understanding the behavior of functions, analyzing data, and predicting future outcomes. This is why they are a critical component of uncertainty analysis. If you are estimating measurement uncertainty without considering probability distributions, you are going to make mistakes. So make sure to use this guide as a reference when calculating uncertainty. Additionally, it never hurts to use the chart below.

I hope that you have found this article helpful for your uncertainty analysis. If I have left anything out of this guide or if you can think of any additional tips that would improve this list, please contact me to share your advice.

References

[1] Castrup, H. (2007). *Distributions for Uncertainty Analysis.* Bakersfield, CA: Integrated Sciences Group.

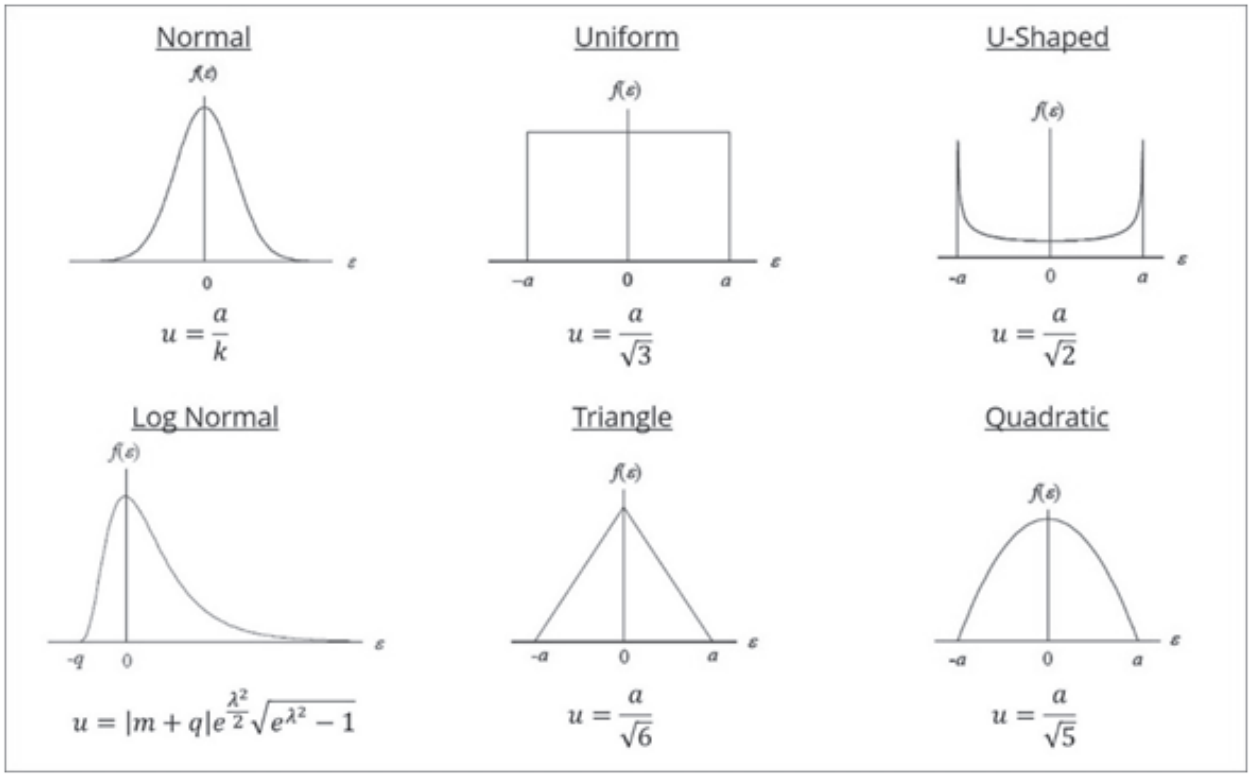
[2] Castrup, H. (2009). *Error Distribution Variances and Other Statistics.* Bakersfield, CA: Integrated Sciences Group.

[3] DeCarlo, L. T. (1997). *On the Meaning and Use of Kurtosis.* American Psychological Association Inc., 292-302.

[4] Dobbert, M., & Gorin, J. (2011). *Revisiting Mismatch Uncertainty with the Rayleigh Distribution.* Santa Rosa: Agilent. http://cp.literature.agilent.com/litweb/pdf/5990-9185EN.pdf.

[5] Petty, N. W., & Dye, S. (2013). *Triangular Distributions.* Christchurch: Statistics Learning Centre.

Richard Hogan, ISOBudgets LLC, P.O. Box 2455, Yorktown, VA 23692, rhogan@isobudgets.com (757) 525-2004, option 1.
http://www.isobudgets.com



PXI Interoperability—How to Achieve Multi-Vendor Interoperability in PXI Systems

Dave Brannon
Keysight Technologies, Inc.

Test system developers generally require a large variety of test instruments to meet system needs. When the instruments are sourced from different suppliers, the system developer must have confidence that they will work well together. Mechanical, electrical and software aspects need to be compatible to ensure successful system operation. Thankfully, due to the work of various standards organizations, the PXI specification promotes hardware and software compatibility between products and suppliers. These organizations defined PCI bus connectivity, chassis, timing, synchronization and software attributes.

PCI Communications

PCI and PCIe® electrical bus structures used in PXI are based on the Personal Computer PCI bus and common chipset and signaling methods developed by the PCI Special Interest Group (PCI-SIG). Since the PCI bus is ubiquitous worldwide, a high level of interoperability is assured by the millions of engineering hours invested over the last two decades. PXI leverages these investments resulting in robust connectivity between modules and chassis, as well as robust boot and messaging processes. At PC boot time, the PC BIOS discovers PCI hardware on the bus (including PXI modules) and the operating system assigns resources including memory and interrupt.

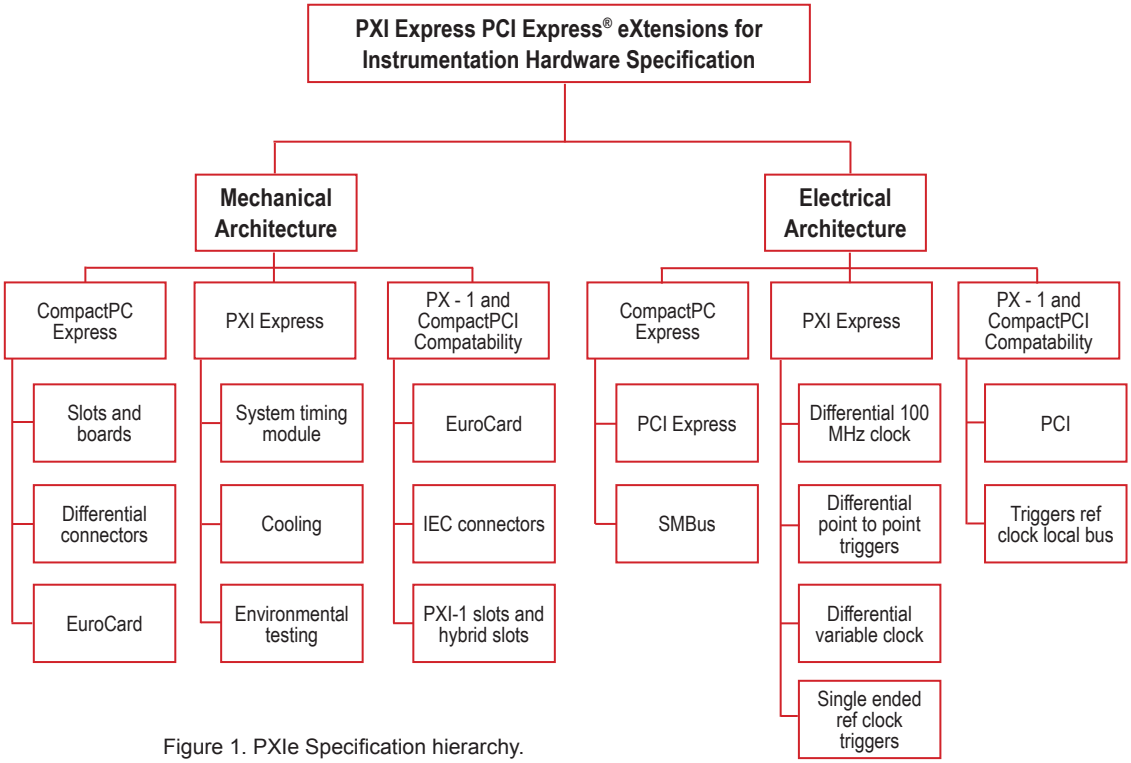


Figure 1. PXIe Specification hierarchy.

Mechanical and Electrical Compatibility

The PCI Industrial Computer Manufacturers Group (PICMG) leveraged PCI bus capabilities to introduce a specification for an industrial grade enclosure known as CompactPCI® (cPCI). Compact PCI was a very good mechanical platform to build from and was quickly adopted in industrial applications. The mechanical slot spacing, connector placement and pin- outs are all defined as part of the cPCI specification. Standard mechanical dimensional constraints and strict tolerances allowed smooth insertion of modules into chassis using common installation levers. These attributes combined with standard connector definitions and pin-outs allow various suppliers to source interchangeable cPCI solutions. However, cPCI had no provisions for timing and synchronization features necessary in instrumentation applications. This is where the PXI stepped in and provided instrumentation specific features.

PXI Specification Ties It All Together

The PXI specification is defined and managed by the PXI Systems Alliance (PXISA). This specification builds on the PCI and cPCI specifications by defining instrumentation specific attributes including timing and synchronization features. A cPCI chassis and a PXI chassis look very similar and cPCI modules can be used in PXI chassis. Figure 1 shows the hierarchy of the PXIe specification. Notice multiple sections where CompactPCI and PCI bus attributes are adopted.

Two variations of PCI bus structures were worked into the PXI specification — the original parallel PCI style (including both 32 and 64-bit structures), and the newer PCIe based serial structures. The original parallel PCI implementation is known as PXI-1 while the serialized PCIe style is known as PXIe. PXIe provides a significant improvement in data bandwidth as well as other features such as point to point messaging which are important in high-end instrumentation applications. Engineers upgrade to PXIe primarily for higher-speed communications features, in addition to improved timing and synchronization built on new high speed differential connectors.

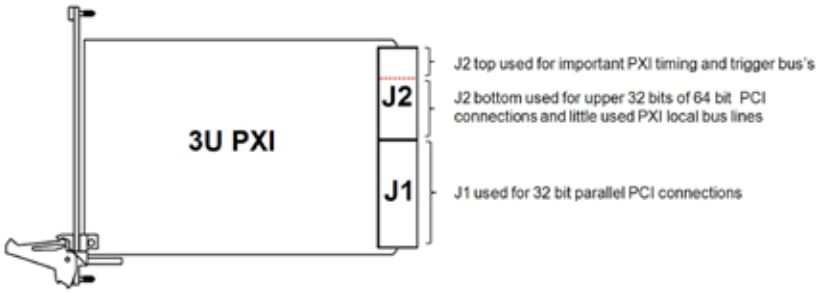


Figure 2. PXI-1 3U PXI module. Notice J1 is used for 32-bit parallel PCI connections.

The PXIe additions also included provisions for PXI-1 backward compatibility. PXI-1 backward compatibility is critical since there are many existing PXI modules that are designed based on the older 32-bit parallel version of PXI. The intent is to allow re-use of those designs without having to modify the basic design including the PCB layout.

PXI Hardware

Module Sizes

PXI modules come in two sizes - referred to as 3U and 6U. The more popular size is the 3U, which is 100 mm x 160 mm. There are over 1000 PXI modules currently available — the majority of which are shipped in the 3U format and use 32-bit PCI bus for communications. Both mechanically and electrically 32-bit, 3U PXI-1 modules are well established and a large variety of modules are currently in production.

Connectors

Figure 2 shows a 3U PXI-1 module. The connections for communications and other functions are routed through connectors J1 and J2 to the chassis backplane. J1 is used for 32-bit PCI

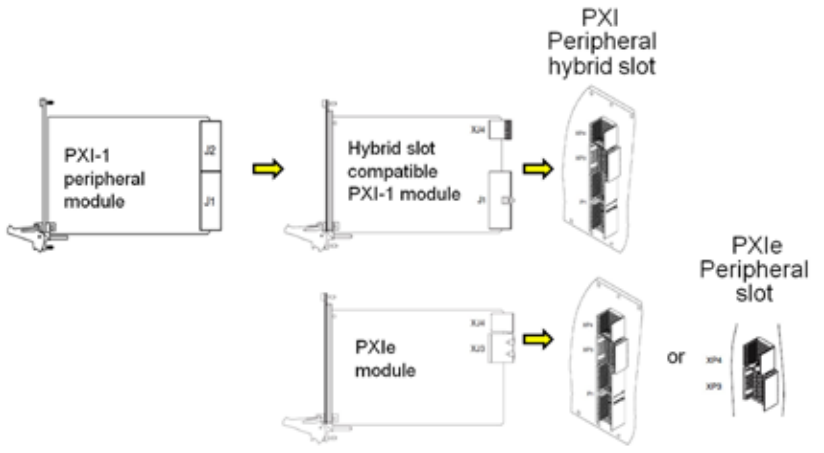


Figure 3. Legacy PXI-1 vs. hybrid and PXIe style modules and slots.

communication connections, and it provides all the signals necessary for 32-bit PXI modules to communicate to the controller. J2 contains the extra upper 32-bits in the event a 64-bit PCI version is supported, as well as additional PXI specific connections to support timing and synchronization.

The standards organizations, challenged to develop a method to route the high speed PCIe connections to PXIe modules that would also be compatible with the original PXI-1 connector footprint, developed a differential style connector to connect to the chassis backplane. Above the red dotted line in Figure 2, critical PXI-1 signals including timing, triggering and local bus lines are routed to the J2 connector. Below the red line, connections are made for upper bits for 64-bit PXI-1 modules and little used PXI local bus connections. The standards organization reutilized the lower portion of J2 to route the high speed PCIe connections and signal routing. With this re-assignment, two new styles of chassis peripheral slots were created: PXIe and Hybrid PXI slots. Figure 3 shows how an existing PXI-1 PCB layout can be redesigned or re-worked using a shorter connector to fit into a hybrid slot and how that same slot can also accommodate a PXIe module.

Figure 4 shows the lower connector with differential connections. This differential connector supports the high speed signals required for PCIe (up to 5 Gbit/sec). The advantage of this new connector configuration is that existing PXI-1 designs can be re-configured by their manufacturer by simply replacing the larger J2 connector footprint with the shorter PXI-1 hybrid slot compatible connector. This allows older module designs to be used in new PXIe chassis that contain hybrid style slots. Older PXI-1 modules with both J1 and J2 installed cannot be plugged into a PXI-1 hybrid style slot. If you have old PXI-1 modules on-hand, visually inspect the connectors to be sure they are compatible. Some PXI module suppliers offer a modifications service to remove the J2 connector and replace with the shorter XJ4 connector. Before purchasing new PXI modules verify with the module supplier that it is available in either hybrid or PXIe format.

Figure 4. PXIe connector style.

PXI Chassis and Controllers

Chassis

The advantages of PXIe include significantly higher throughput, point-to-point messaging and improved triggering and synchronization. To support both PXI-1 and PXIe style modules, it is helpful to have many hybrid compatible slots in the PXIe chassis. For maximum flexibility and interoperability, select a chassis with all hybrid slots to provide slots for both PXI-1 Hybrid and PXIe style modules. The Keysight M9018A chassis has been designed to maximize the number of hybrid slots. If you are using PXI-1 modules with the J2 connector, select a chassis with PXI-1 slots or make sure you can convert these to PXI-1 hybrid modules.

PXI Controllers

Controllers or personal computers (PC) can be located either outside the PXI chassis or embedded in the PXI chassis (installed into the chassis slot 1).

External Controllers

Based on the PCIe communications protocol, PCIe buses use standard COTS connectors, cables and chipsets. Keep in mind, when controlling a PXIe chassis there may be a long cable connecting the controller to the chassis. The long cable will impact signal loading and can inversely impact the eye opening for the high speed PCIe data. For optimal driver capabilities, equalization can be applied to the PCIe drivers improving the ability to drive long cables. Clock jitter can also impact PCIe communications, especially at the PCIe Gen 2 or higher rates. PCIe adaptor cards are available that can isolate and then re-generate a lower jitter PCIe clock to be used when decoding the PCIe message.

To address PCIe signal drive and clock jitter concerns, select a proven PCIe adaptor card product. For example, the Keysight M9048A PCIe adaptor card has been engineered to provide PCIe drivers optimized to drive external PCIe cables. In addition the M9048A provides clock isolation also improving high speed PCIe data transmission. The M9048A clock isolation circuits are engineered to keep clock to data jitter extremely low, improving the timing margins at the PCIe receivers.

The enumeration process can also be impacted by the controller BIOS.

To enumerate a full-sized PXIe chassis, 30 or more PCI end points must be enumerated during the PC boot process. The number of PCI endpoints supported by BIOS in some business grade controllers (PCs) may be limited since business applications typically only need a few PCI endpoints. When using an external controller, select one that has been pre-tested to verify BIOS and signal characteristics are suitable for full enumeration of the PXIe chassls. Keysight has pre-tested popular PC controllers to verify operation. If you plan to use an external controller it is best to select one that has been pre-tested to verify BIOS are suitable for full enumeration of the PXIe chassis.

Embedded Controllers

An embedded controller, specifically designed for use in slot 1 of the PXI chassis, can be used to control PXI instruments. If you are considering using an embedded controller it is important to note that the backplane connections for PXI-1 style controllers are different than PXIe controllers. PXI-1 controllers route the 32-bit parallel PCI bus while PXIe controllers route the high speed PCIe signals. The connectors are physically different and as such a PXI-1 controller cannot be used in a PXIe chassis. When selecting an embedded controller to use in a PXIe chassis keep in mind the controller must also be a PXIe style controller.

Software

Just as the PCI electrical specifications provide a framework for electrical connectivity, the PCI device driver provides a common framework for software access. For improved usability and supportability, the driver stack usually is partitioned into multiple layers. Application software access to a module is always provided through the instrument driver. This may consist of an IVI driver, VISA driver and kernel driver. These three layers of software form a tightly coupled group that work together. Figure 5 shows the software stack used to communicate to Keysight PXI modules.

Conclusion

PXI chassis, controllers and instrumentation are based on standards maintained by the PCI-SIG, PICMG and PXISA organizations. These standards provide both the user and vendor several advantages including leveraging components and engineering investments made for high volume PC businesses. Common PCI bus inspection tools such as Microsoft Windows Device Manager give an independent verification of the PXI module driver installation and operation. Instrument suppliers that adhere to these standards go a long way to ensuring multi-vendor interoperability.

For the complete application note, visit: **www.keysight.com/find/7modulartips**.

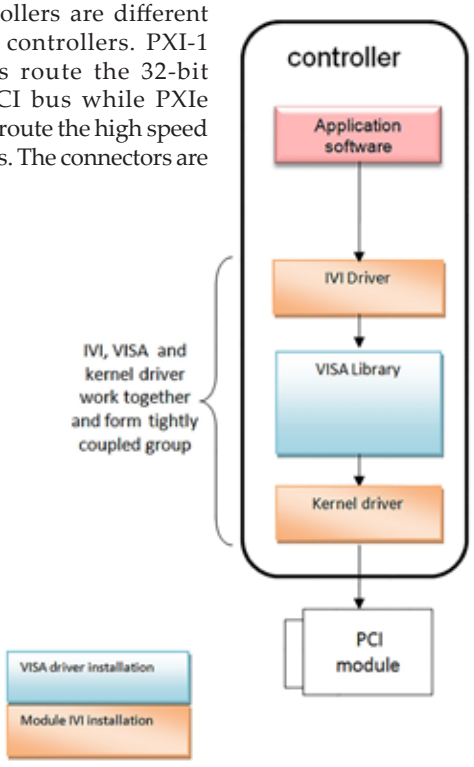


Figure 5. Software stack used to access Keysight PXI modules.

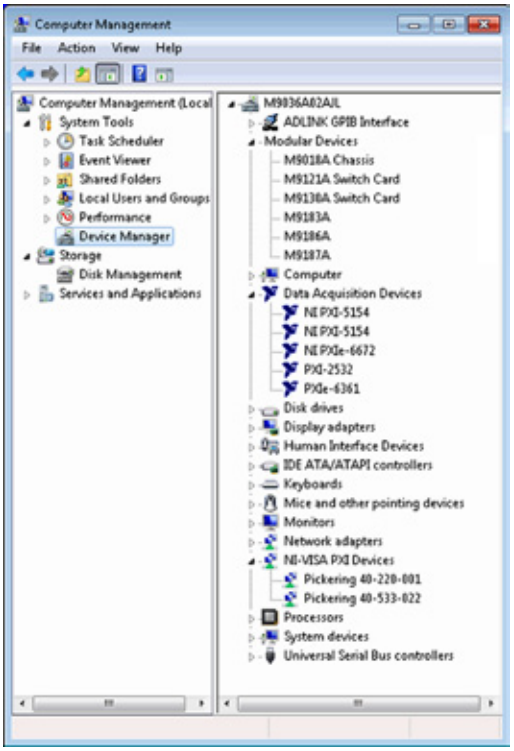


Figure 6. PXI instruments as they appear in Microsoft Windows Device Manager.

Accreditation to ISO/IEC 17025: Understanding the Benefits and the Process

Roger Muse
ANSI–ASQ National Accreditation Board

To the uninitiated, accreditation to ISO/IEC 17025 can seem mysterious, confusing, or downright daunting. Just what does accreditation mean? And exactly how is it accomplished?

Broadly speaking, accreditation is the means by which an authoritative body provides formal recognition that an organization is competent to carry out specific tasks. Accreditation to ISO/IEC 17025 by an accreditation body that is a signatory of the International Laboratory Accreditation Cooperation (ILAC) mutual recognition arrangement (MRA) provides assurance to an accredited organization's customers that the organization continues to operate according to internationally accepted criteria. Internationally recognized accreditation can also help you ensure consistent operations, move your organization toward the desired recognition, and help you sustain a competitive advantage.

All ILAC MRA signatories must comply with the requirements ISO/IEC 17011, Conformity assessment - General requirements for accreditation bodies accrediting conformity assessment bodies. But each accreditation body has the flexibility to design its accreditation process within the constraints of the standard.

The ANSI-ASQ National Accreditation Board (ANAB) developed its laboratory accreditation process not just to ensure compliance with international requirements but also with the intent of maintaining the highest integrity while minimizing disruption and cost to the customer. ANAB's accreditation process is recognized within the United States and internationally as providing superior service in many areas of calibration and testing and for ANAB's ability to provide accreditation for unique scopes and customized areas of testing.

The process of accreditation typically begins when an interested party provides the accreditation body with information on the desired scope of accreditation, size of the organization, number of employees, and locations where activities to be covered under the scope of accreditation will be conducted. Based on this information, the accreditation body develops and provides a **quote** that includes estimated fees for the entire accreditation process, including surveillance and reassessment. In other words, the quote provides the potential customer with more than just the cost of initial accreditation; it also indicates the cost of maintaining accreditation through a full cycle.

The applicant laboratory is required to submit a completed **application** package consisting of:

- Completed application form, including all relevant locations to be covered by the accreditation
- Quality management system documentation, including the organization's quality manual and copies of procedures and work instructions
- Organizational structure, specifically noting the persons or organizations responsible for assigning the property values of all artifact types related to the application for accreditation
- List of all relevant experts, if applicable
- List of artifact suppliers
- Example report for each proficiency test for which accreditation is sought

As part of the application process, the applicant submits information about the desired **scope of accreditation**. A laboratory need not become accredited for all of its capabilities. The scope of accreditation defines the specific calibrations and/or test methods for which the accreditation applies. For suppliers seeking competent facilities, accreditation to ISO/IEC 17025 for the required scope of calibration or testing provides the needed assurance.

Prior to the initial accreditation assessment, ANAB conducts a **document review** to verify that the applicant has documented all management system requirements outlined in ISO/IEC 17025 and any other applicable requirements. Additional requirements could include, for example, scheme documents if the applicant is seeking accreditation to ISO/IEC 17025 and a scheme based on the standard but with additional requirements. ANAB provides the applicant a report containing the results of

the document review. Depending on the severity of gaps identified, the applicant may be asked to address issues before the on-site assessment is conducted.

Organizations also may opt for an **introductory visit** and/or **practice assessment** to better prepare for the accreditation process. Both of these are optional and not required for accreditation.

Typically the accreditation body works with the applicant to determine an assessment schedule agreeable to all parties. Approximately a month prior to the **accreditation assessment**, the applicant receives the assessment schedule and plan. During the on-site assessment, the assessment team samples applicant's technical competence and quality management system and determines through interviews and by reviewing procedures, data, and records whether or not the customer's system is effectively implemented and meets all of the applicable requirements. Technical assessors conduct a thorough evaluation of all factors relevant to the laboratory's ability to produce precise, accurate calibration and test data.

Any deficiencies in the management system or technical competence that are identified during the assessment are documented as nonconformities (NCs). Any such findings and the anticipated timeframe for their closure are discussed at the closing meeting held at the end of the assessment.

For any NCs identified during the assessment, the applicant is required to provide **corrective action** within 30 days after the conclusion of the on-site assessment. Following acceptance of the corrective action submitted by the applicant, ANAB begins the accreditation decision process. In some cases, a follow-up visit may be scheduled prior to the accreditation decision.

To ensure an impartial **accreditation decision**, members of the assessment team do not take part in the decision. The designated decision maker is responsible for reviewing the assessment team's recommendation and for ensuring that all accreditation requirements have been met by the applicant and are properly documented before granting accreditation.

The accreditation body issues a certificate and scope of accreditation after favorable accreditation decision.

ANAB establishes **surveillance and reassessment** plans based on the accredited customer's proven stability and competence. Typically the cycle consists of on-site assessments every other year and surveillance in alternating years. ANAB designs the reassessment and surveillance plan for each accredited organization to ensure representative samples of the scope of accreditation are assessed on a regular basis.

The ANSI-ASQ National Accreditation Board (ANAB) provides accreditation for ISO/IEC 17020 inspection bodies and forensic inspection agencies, ISO/IEC 17025 testing and calibration laboratories and forensic testing agencies, ISO Guide 34 reference material producers, ISO/IEC 17043 proficiency test providers, ISO 15189 medical test laboratories, ISO/IEC 17021 management systems certification bodies, and industry-specific programs. ANAB cooperates with other accreditation bodies around the world to provide value to the organizations it has accredited and their clients, ensuring that accredited certificates and test results are recognized nationally and internationally. The global conformity assessment system ensures confidence and reduces risk for customers engaging in trade worldwide. For more information, visit **www.anab.org**.

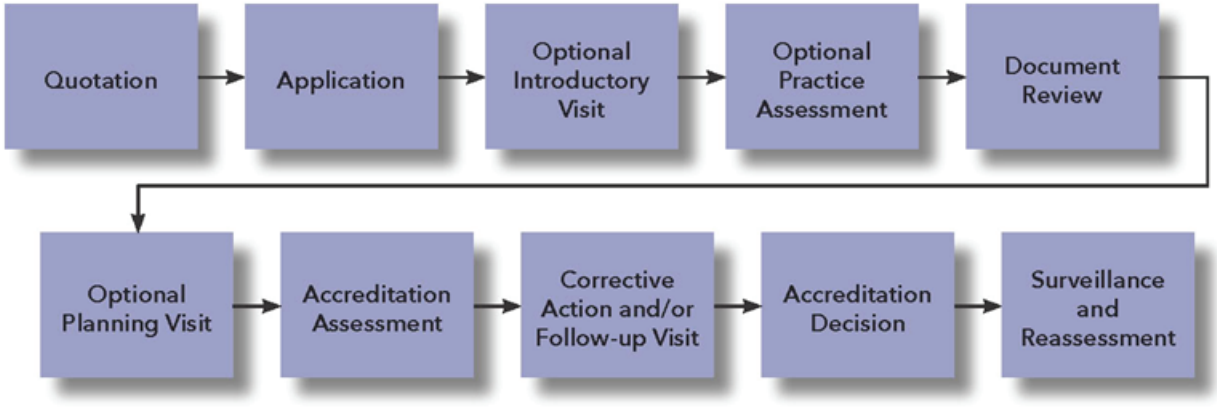


Figure 1. ANAB Accreditation Process

Training Resources for Business

Sita Schwartz
Editor

US calibration labs have challenges like any other business, including employing a skilled and well-trained workforce. In a tight economy, there still exist some resources to assist businesses with training. Motivated management and/or employees can get involved in finding assistance to help fund their own training. Some resources can even overlap in what they provide to help source quality improvement measures and improve their overall working environment and company productivity. Given effort and opportunity, businesses can benefit from the information that is out there.

Federal and State Resources

NIST Hollings Manufacturing Extension Partnership (MEP)

MEP partners up with organizations at the federal, state, and local levels to help address a number of issues for clients such as quality, sourcing, and innovation.

Example: Through New York Manufacturing Extension Partnership, MEP was able to help facilitate a manufacturer of ice and snow removal equipment to commission an affiliate to conduct Lean Principles Training, Value Stream Mapping Training & Implementation, Lean Leadership program, & Lean White Belt Training. Ultimately, capitol investments by this company sped up their production and sales grew, leading to new hires. Another effect of company-wide training led to improved employee engagement in the flow of ideas and improvement initiatives coming from the shop floor.

MEP has 440 field locations throughout the US & Puerto Rico. To learn more about NIST MEP and find a local MEP office, visit the website: www.nist/gov/mep/.

GRANTS.gov

Grants.gov lists federal funding opportunities across all the different government agencies—mainly for research. As an example, metrology industry related opportunities recently solicited by NIST, under the Department of Commerce, is the Measurement Science and Engineering (MSE) Research Grant and Precision Measurement Grant Program (PMGP).

Conducting searches through such a broad government tool can also lead to other discoveries (non-solicitations) you might not expect, such as the National Defense Science and Engineering Graduate (NDSEG) Fellowships (http://ndseg.asee.org/).

Registered Apprenticeship Program

The National Apprenticeship Act (Fitzgerald Act) was enacted in 1937. Facilitated by the DOL, employers can register to become part of this program (http://www.dol.gov/featured/apprenticeship). In return, they are eligible for grants and assistance in finding and training new or existing employees. "Calibration Laboratory Technician" is included as an available occupation (https://www.doleta.gov/OA/occupations.cfm).

In the past, businesses with a large enough work force often coordinated with the unions in order to provide on-the-job training and apprenticeship programs. But, coordination with an industry union is NOT required; therefore, business should not be turned off by an apprenticeship program.

DOLETA.gov

Besides federal government job training and worker dislocation programs, the DOL Employment and Training Administration (ETA) administer federal grants to the state and local level through workforce development systems. Factoid: To address unemployment, the US Department of Labor (DOL) announced $169,771,960 in grants as part of the Ready to Work initiative, back in October 2014.

From DOLETA.gov, you can find a number of other federal websites geared towards connecting the unemployed with training opportunities—though there are some links that provide resources for businesses as well:

- **Americanjobcenter** (http://jobcenter.usa.gov/) is a hub for finding government resources available to students, job seekers, veterans, and business.
- **Veterans Employment Center**™ (https://www.vets.gov/veterans-employment-center) helps connect veterans seeking employment with employers.
- **Careeronestop.org** (http://www.careeronestop.org/BusinessCenter/index.aspx) provides information on State and Federal Grants, Work Opportunity Tax Credit, On the Job Training (OJT), and Workforce Development Boards (WDB).
- **Workforce³ One** (https://www.workforce3one.org/) is yet another website for finding resources for "Workforce System Success." Head spinning yet? Mine is. But from here you can find an online **grant application toolkit** (https://www.workforce3one.org/ws/www/pages/grants_toolkit.aspx?pparams=).

Working with Schools

Though community colleges are increasingly dropping their metrology programs, they are a critical player in retaining a "middle-skills" workforce. Community Colleges, Public Vocational Schools, and State Colleges and Universities often work with businesses. The relationship is mutually beneficial and regularly implemented in countries all over the globe. In fact, states encourage this kind of collaboration through economic/workforce development grants. State funded programs for retraining vary from state to state. It's in their best interest to help support industry; just as states need tax revenue, business needs to sustain a well-trained workforce to remain competitive.

Some examples of how industry can work with community colleges:

- Companies registered with the federal apprenticeship program can send their employees to participating community colleges and have the tuition covered in whole or part.
- Companies can work with community colleges and vocational schools to tailor curriculum for a company's specific training needs.

In Conclusion

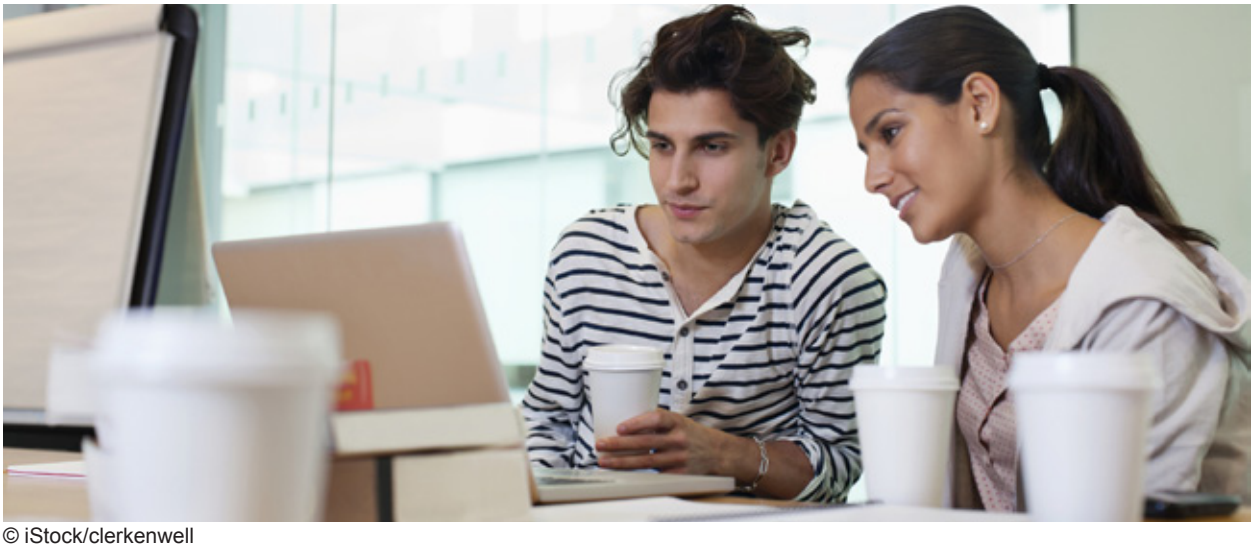
Businesses can take advantage of funding and/or other resources if they do their homework. In a nutshell, the US government funds initiatives for employment and training programs that are implemented at the state and local level. Some of this is in the form of grants—particularly for research—but mostly it's about networking and providing the public with information.

Thanks to Paul Hanssen of WorkPlace Training, www.wptraining.com, for the idea to write this article.

The Benefits of a Sustaining a Well-Trained Workforce

For the sake of keeping this article focused and brief, I've left out extolling the virtues of providing continuing education to employees and how companies can benefit from the results—there's plenty of reading material out there for anyone interested:

- Thomas Kochan, David Finegold, and Paul Osterman, "Who Can Fix the 'Middle-Skills' Gap?" *Harvard Business Review*, vol. 90: 12, December 2012.
- "Key Asia-Pacific Officials, Experts Discuss Critical Importance of Standards Education," NIST Standards Coordination Office, March 4, 2011 (http://www.nist.gov/director/sco/standards-education-030411.cfm).
- Nicholas Wyman. "Launching A Mentored Apprenticeship Model: How And Why." *Benefits Magazine* 52.11 (2015): 36. MasterFILE Premier. Web. 20 Jan. 2016.
- Anthony Carnevale and Nicole Smith. "Skills Match." *Community College Journal*, December 2012/January 2013.
- Giffi et.al. *The Skills Gap in US Manufacturing: 2015 and Beyond*, Deloitte Development LLC. 2015.
- *What Works in Job Training: A Synthesis of the Evidence*. U.S. Dept. of Labor, U.S. Dept. of Commerce, U.S. Dept. of Education, U.S. Dept. of Health and Human Services, July 22, 2014 (http://www.dol.gov/asp/evaluation/jdt/jdt.pdf).



NEW PRODUCTS AND SERVICES

Pasternack Rackmount RF Amplifier

Irvine, CA - Pasternack, a leading provider of RF, microwave and millimeter wave products, introduces a brand new rackmount variable gain RF amplifier with performance from 100 MHz to 18 GHz. This 19-inch rack mounted RF amplifier is designed for lab use and various test and measurement applications. Normally this type of test equipment commands long lead-times for delivery often exceeding several months; however, Pasternack has made this product available from stock for immediate shipment.

Pasternack's new rack mount RF amplifier offers broadband frequency coverage from 100 MHz to 18 GHz with high gain levels of 50 dB minimum over a temperature range of -40°C to +85°C. Integrated digitally controlled attenuators boast dynamic range up to 60 dB with a 1 dB step size. Typical performance includes 6.5 dB noise figure and +14 dBm output P1dB. The package design supports a front panel LED display with manual control dial and SMA connectors, and a 9 pin D-Sub Miniature connector on the rear panel. It is also environmentally sealed and designed to meet a series of MIL-STD-202F test conditions.

The PE15A7000 variable gain amplifier can be used on a test bench, but is also designed to fit into rack mount cabinet enclosures (size: 1U high and 10 inches deep). Offering control flexibility, the gain level with precise attenuation step size over a wide frequency band can be manually controlled, or utilize the included RS-232 serial cable and Ethernet connection to link with a PC computer to command control for automated testing (ATE) applications which could involve production testing over temperature or research and development projects.

Pasternack's new rackmount variable gain RF amplifier is in-stock and ready to ship today. You can view the new amplifier by visiting http://www.pasternack.com/pages/Featured_Products/rack-mount-variable-gain-amplifier.htm.

New ComScan 3D System

(BATAVIA, Ill)—A revolutionary 3D scanning technology from ComScan, a developer of automated 3D scanning solutions based near Chicago, is revolutionizing gauge reproducibility and repeatability testing (R&R). The new ComScan system innovatively combines optical, 3D scanning measurement technology with traditional gauge R&R for unparalleled precision and ease of use.

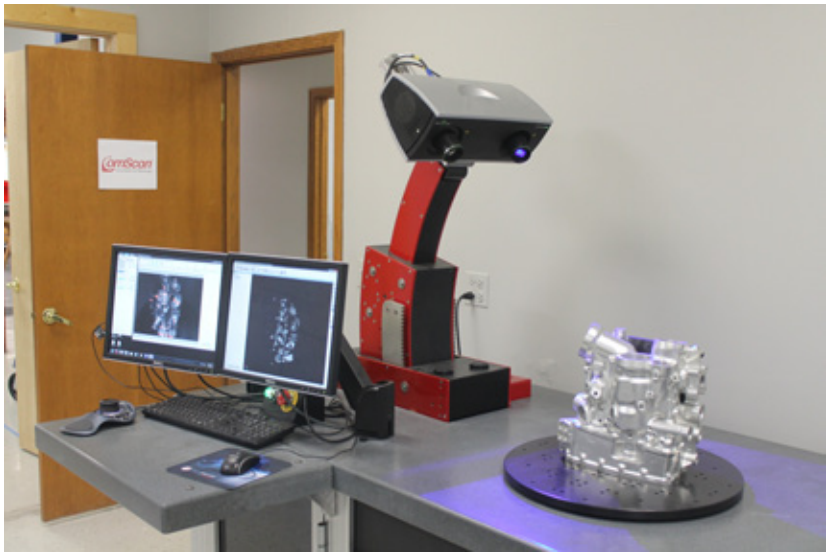
"For companies needing to inspect multiple piece parts with complex geometry, our system offers precision in R & R that has never been seen before. By applying our 3D scanner technology, we're able to produce a proven less than ten microns repeatability!" said Steve Gaspardo, developer of ComScan and President of Gaspardo & Associates, the engineering firm responsible for the new machine. The unit has been in development since 2005. Applications are expected in the medical, aerospace and automotive industries.

The system includes the 3D scanner unit and the PolyWorks software. The ComScan system's scanner lens measures diffraction limits up to two point nanometers of accuracy, and its detector array fits onto a single chip. Instead of a probe, the machine uses a rotating surface to measure the specimen from five axes of movement. However, the table has a fitting for the test specimen, so reproducibility is virtually eliminated since all operators need to do is load the part and press start. The PolyWorks software then automatically stitches together multiple test measurements to form a 3D volume and merges the data for editing.

"We've even proven the precision of the ComScan system on the gold standard of absolute true value—a surveillance master," said Gaspardo. The surveillance master test has been reviewed in detail within a technical whitepaper by David Jenkins, Ph.D entitled "Gauge R & R with ComScan Automated 3D Scanning Solutions" which is available for free download at http://www.comscan.biz/gagerandr. A video of the ComScan system is also available on the website.

About ComScan

Gaspardo & Associates is based in Batavia, IL outside of Chicago and began as an engineering firm and metrology laboratory in 1996. The company developed the ComScan system with a suite of affordable 3D scanning solutions and products that combine automation typically found in coordinate measurement machine applications. For more information on ComScan products, visit www.comscan.biz or call 630.761.8800.



Aircraft FMU.

NEW PRODUCTS AND SERVICES

Michell Instruments HygroCal100

The HygroCal100 humidity validator. weighing just 3.2 kg, it is less than a ¼ of the weight of its closest competitor and with a battery life of up to 8 hours.

The humidity test chamber is highly stable and allows the evaluation of relative humidity sensors in the range of 5 to 95% RH. Up to seven probes, with different diameters and output signals, can be validated simultaneously. The HygroCal100's innovative design allows the probes to be integrated with the chamber and user interface enabling the operator to easily monitor the readings of each probe during the calibration cycle. In addition, all the calibration data can be downloaded from the unit on to a USB drive for later use.

An external reference hygrometer, such as Michell's fundamental, chilled mirror Optidew Vision, can be integrated into the system. If this reference has a traceable calibration, it allows users to incorporate this traceability into their verifications.

The unit is easily programmable through its touch-screen interface enabling calibration routines to be completely automated. The operator defines the humidity points, and time to remain at each of them, inserts the probes and the reference, then leaves the unit to work through the cycle.

The HygroCal100 contains an internal polymer reference – Michell's latest generation HS3 sensor, giving class-leading ±0.8%rh accuracy. For long term reliability, the HygroCal100 can be calibrated against an external reference. Once the reference is connected and the calibration initiated, the HygroCal100 automatically runs through the steps and prompts the user for actions.

http://www.michell.com/us/

PJVS Commissioned at the Oak Ridge National Laboratory

12/9/2015 - The Oak Ridge National Laboratory's (ORNL) Metrology Lab recently received and commissioned the first commercial cryo-cooled, Programmable Josephson Voltage Standard (PJVS) built by NIST. The PJVS is capable of generating programmable direct-current voltages over the range of -10 V to +10 V by a combination of biasing arrays of Josephson Junctions into either positive, zero or negative voltage steps and varying RF frequency excitation, thereby creating voltage steps over the entire range of -10 V to + 10 V accurate to within a few parts in 1012. The voltages generated by the PJVS can be used to calibrate Zener reference diodes or other DC reference standards, which serve as the primary voltage references for many calibration laboratories.

Another feature of the PJVS is its ability to generate stepwise-approximated sine waves, which combined with a differential sampling technique, is capable of generating AC voltages outputs with uncertainties to within a few parts in 107. These AC Voltage outputs can be used for calibrating AC voltage standards typically used in calibration laboratories.

The PJVS system at the ORNL Metrology Laboratory is also cryo-cooled thereby eliminating the need for liquid helium to reach superconducting temperatures. In addition to eliminating the hazards and expense associated with liquid helium, this means that the ORNL Metrology Laboratory is able to provide on-demand calibrations for both AC and DC voltage standards and measuring equipment without being enslaved to helium delivery and endurance schedules. It is anticipated that the ORNL PJVS DC-voltage capabilities will be added to the ORNL Metrology Laboratory's scope of accreditation in early 2016, with AC-voltage capabilities to follow shortly thereafter.

Longer-range plans are for a Quantum Hall Resistance Standard to be added to the ORNL Metrology Laboratory's capabilities, which together with the PJVS capability, will eventually provide fully-intrinsic traceability for measurements to the SI unit of the Ampere.

For more information, contact Mike Duncan, ORNL Metrology Manager at 865-574-7349 or duncanml@ornl.gov.

The ORNL PJVS system with ORNL and NIST technical staff.

queensgate

Queensgate NX NanoSensor® High Resolution Position Sensor

Employing capacitance micrometry, the NX NanoSensor® from Queensgate delivers sensitivity levels that are able to measure changes in position to an atomic scale. This state-of-the-art non-contact position measuring system relies on 2 sensor plates - a target and a probe, which between them form a parallel plate capacitor. Through the use of an appropriate electronic controller, the spacing of these two plates can be accurately ascertained. Among the key applications for the NX NanoSensor are stage feedback, vibration measurement, metrology, deformation measurements, precision manufacturing, drift measurement, precision beam steering and microscopy.

Via NX NanoSensor position can be determined to a margin of better than 7pm, with a linearity to 0.02% and a bandwidth from 50Hz up to 10KHz. There is provision for the system to be tuned so that either the positional accuracy is improved or conversely the responsiveness to dynamic motion is heightened. Plate shapes that are round, square or rectangular can be selected. Active areas of 22.5mm2, 113mm2 and 282mm2 are offered. Working in tandem with the NX NanoSensor, the NS2000 controller module measures any changes in the parallel plate capacitance and subsequently produces an analogue voltage that is directly proportional to the difference in position of the target and a probe sensor plates.

The non-contact measurement and non-self-heating mechanism means that NX NanoSensor products do not impact the values they are measuring, thereby giving true nanoscale measurements. Furthermore, they use a non-hysteretic technique, which means the position is repeatable. Numerous material options can be used in their construction; Super-Invar, Zerdur, aluminium, stainless steel and ceramic - allowing thermal properties to be matched to the stability required by the specific application, in order to safeguard against position drift. Ultra high vacuum, radiation hardened, non-magnetic and cryogenic variants can be specified.

For more information visit: http://www.nanopositioning.com.

Mettler Toledo's Constant Pressure Mass Comparator

(Greifensee, Switzerland) – National Measurement Institutes (NMI's) and Calibration Laboratories can now reduce uncertainty by measuring mass standards within a constant pressure.

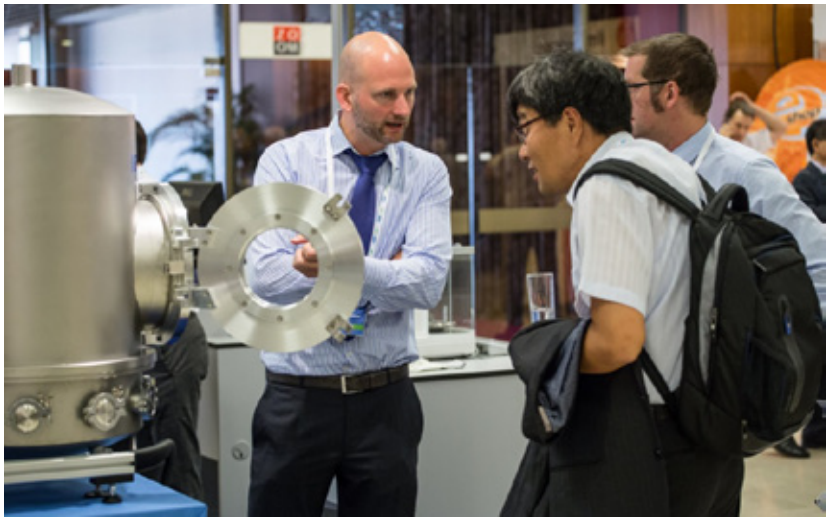
James Berry of the UK's National Physics Laboratory (NPL) states, "The AX1007CP mass comparator has an excellent characteristic regarding the linearity of is sensitivity curve. This meets the aim of reducing the mass comparator uncertainty component in the overall uncertainty budget."

Up to four 1 kg artefacts can be automatically compared with 0.1 µg resolution at a constant pressure to reduce measurement uncertainty when calibrating against national or industry standards.

The AX1007CP automatic mass comparator, introduced at the International Measurement Confederation IMEKO World Congress XXI in Prague, allows fast and accurate mass comparisons to enable NMIs to disseminate traceability from their national standard at extremely high resolution. It is now available for placement worldwide after the successful piloting of three units in key installations in the UK, Australia and Canada.

The AX1007CP represents a complete mass determination solution comprising a mass comparator, a controller unit and AX control software. Software control facilitates both automatic operation and traceable, secure results. Direct data export to laboratory information management systems (LIMS) and automatic climate data acquisition allow compensation calculations for air buoyancy correction, providing secure results of the highest accuracy.

For more information, please visit METTLER TOLEDO online (http://www.mt.com/comparators) or contact Julian Luescher at julian.luescher@mt.com or +41 44 944 2307.



The world's first table-top constant-pressure automatic mass comparator capable of weighing 1 kg artefacts at 0.1 µg resolution is now available globally.

NEW PRODUCTS AND SERVICES

Falco Systems WMA-100

(Amsterdam, The Netherlands) - Falco Systems introduces a new, compact and all-round high voltage amplifier for laboratory use: the WMA-100. It offers a wide range output voltage (±175V), DC offset control, and impressive bandwidth (DC-500kHz) and noise (350 uVrms) specifications. This new amplifier generates no overshoot with any capacitive load. Combined with its modest price and small form factor, it is the ideal choice for any experiment that requires a high quality and reliable high voltage amplifier.

Specifications

- 20x amplification up to +175V and -175V output voltage (with respect to ground)
- DC to 500kHz at (-3dB) large signal bandwidth and 100 mA output current
- Very low noise at ~350 uVrms; even lower when capacitive loads are driven
- No overshoot with capacitive loads; bandwidth changes automatically to ensure stability
- Short-circuit protected output
- Adjustable DC offset control knob
- Available from stock, in a 230V and 115V version

Applications

Typical applications include the use of the WMA-100 amplifier as a high speed, low noise piezo driver, an amplifier for actuating MEMS devices, or for steering EO-modulators. It can also be used as a stand-alone low noise high voltage power supply.

Falco Systems

Falco Systems (est. 2006) designs and manufactures technology leading high voltage amplifiers for company R&D departments, research institutes and universities worldwide. For more information, visit www.falco-systems.com.

NAPT's QMS Navigator

(Edina, MN) – National Association for Proficiency Testing (NAPT), an ISO 17043 accredited proficiency testing provider, announces the release of its innovative Quality Management Software, QMS Navigator. This dynamic software is a true companion to supporting ISO 17043 and ISO 17025 laboratories wanting to improve their quality systems. QMS Navigator is built on 20+ years' experience providing proficiency testing management in the metrology community.

"The Metrology Community's most comprehensive statistical software & management tool for conducting comparisons and managing quality requirements."

QMS Navigator offers all the tools needed to save time, reduce costs, and increase visibility into your quality management system. Proficiency testing becomes streamlined using the built in statistical analysis following ISO 17043 requirements. QMS Navigator is cloud based making it accessible from any internet browser.

To experience how QMS Navigator can steer your lab in the right direction visit: http://www.proficiency.org/Services/QMS-Navigator.

For more information about QMS Navigator, please contact NAPT at 952-303-6126 or send an email to napt@proficiency.org.

New Sorensen ASD FLX DC Power Supplies Feature

AMETEK Programmable Power, the global leader in programmable AC and DC power test solutions (programmablepower.com), introduces the Sorensen ASD FLX Series with a new modular design that allows easy access and flexible voltage assignments.

The water-cooled ASD FLX Series, which offers industry-leading power density (30 kW in a 3U form factor), can now accommodate up to three front-loading modules that can be configured for either 60V or 40V operation (other voltages coming soon) via convenient rear panel dip switches. Despite its 3U size, the ASD FLX's lightweight chassis allows for easy one-person installation.

The new modular Sorensen ASD FLX Series provides excellent load transient response with outstanding output ripple and noise specifications. Load regulation for both voltage and current is 0.1% of full scale, and the maximum RMS noise is 40 mV. A 50% step load will recover to within 0.75% of original value within 1 ms. Programmable filter bandwidth of the output voltage, current and power monitors lets users customize the load response to their applications.

The unit's water-cooled design makes it ideal for harsh or demanding applications with stringent air quality requirements, such as clean rooms or industrial environments that are dirty or potentially corrosive and damaging to air-cooled power supplies.

Optional advanced features of the ASD FLX also allow users to program different "fault levels," enabling detection of output cabling, connections or load problems before they cause critical system problems. Its factory flight data recorder feature has the ability to record parameters such as voltage, current, power, load impedance, faults and input voltages, allowing the factory to easily determine "why" a user has had an unexpected outcome.

With its advanced digital monitoring and control features and flexible voltage assignment modules, combined with industry-leading power density and reliability, the Sorensen ASD FLX is the power supply of choice for stringent and high-value processes and applications.

To learn more, contact AMETEK Programmable Power Sales at 800-733-5427, or from an authorized AMETEK Programmable Power sales representative, who can be located by visiting http://www.programmablepower.com/contact/.

Interfacing with Instrumentation

Michael Schwartz
Cal Lab Solutions, Inc.

Ever since I got into the metrology field, I have witnessed several changes related to how we interface with the test equipment. In the 1980s, there was very little automation; all the standards I had in my lab had a manual interface. Then shortly thereafter, computer control instruments started appearing on the market with RS232 or HPIB/GPIB interfaces. Now, the computer could send the instrument a string of information that instructed the setting on the instrument. This was great—what could take several minutes could now be accomplished in milliseconds.

Today we are in the midst of another great change in instrumentation with software based instruments. As computers, memory and buss speeds get even faster, so are the capabilities of our instrumentation. One project we worked on last year we were able to take 64k samples of data and compute an FFT, then average 32 FFTs, measure the average power in 5 frequency bands, and return the results in just over one second!

To me that was amazingly fast, but it presented a problem: How is a calibration lab going to support the new instruments and all the old instruments in a single platform? The industry needs a support strategy that covers all metrology disciplines and all forms of instrument control—manual, command, and software based instruments. Each of these interfaces presents a unique challenge in software and how we design the next generation of metrology software.

One would think a manually controlled user interface is the easiest of all the interfaces to deal with, but it's not. To me it is the hardest and most problematic to deal with. First you have to give clear and concise instructions to the operator on how to properly set up an instrument. The operator has to understand these instructions and properly execute them. And in the end, you have no way to verify the instrument is set up correctly. You have to trust the operator's skills level.

Many years back I had the opportunity to run some scope calibration software from Tektronix. They did a very interesting thing by programming all the settings into a state machine. This allowed the technician to see only the settings he needed to change from one settings state to the other, or see all the settings on the instrument. I really liked the usability of feature and have used it in many of my solutions.

Command controlled instruments are the most common instruments we see in the calibration lab. They are simple and relatively easy to program. Most are VISA, RS232, IEEE 488.2 or LXI compliant which function on the same basic principle of text based commands. These instruments are relatively easy to interface with so I will not go into much detail.

Newer, software based instruments are for most calibration technicians much harder to interact with and control. Some manufactures like National Instruments and Keysight Technologies have done a very good job at providing users with drivers.

These instruments are designed to be installed in a dedicated system and present themselves as being fast and inexpensive compared to traditional equipment. They usually have a dll, COM Object or some other type of driver library that is directly called from the software installed on the system. This is great for the system and the end users, but it is difficult for the calibration lab to support, mostly because the calibration of modular instruments usually requires it to be moved into another calibration system owned by the calibration lab. This in itself is not huge problem, but to support these modular instruments the calibration lab has to own several different systems—one for each type and generation of hardware they are supporting.

One area where we can update and improve upon is how we interface with modular/software based instruments. Just because the manufacturer didn't provide a text based, command interface for the instrument doesn't mean it can't be easily added. A relatively simple program can be written and installed on the same system with the software based instrument. This then allows the instrument to be called remotely—similar to how you control GPIB instruments. It is worth reading "An Enterprise Resource View of Metrology Software Systems," a paper I presented at NCSLI on how to do this in MET/CAL® and check out www.Metrology.NET, a system-of-systems approach to metrology.

Software based instrument as well as manually controlled instruments both present very different challenges when it comes to how we interface with them through our software. When we are designing our software and automation we should keep in mind that not all instruments will be controlled with text commands. Making allowance for both extremes will be beneficial in the long run. ❧

CPEM 2016

Conference on Precision Electromagnetic Measurements

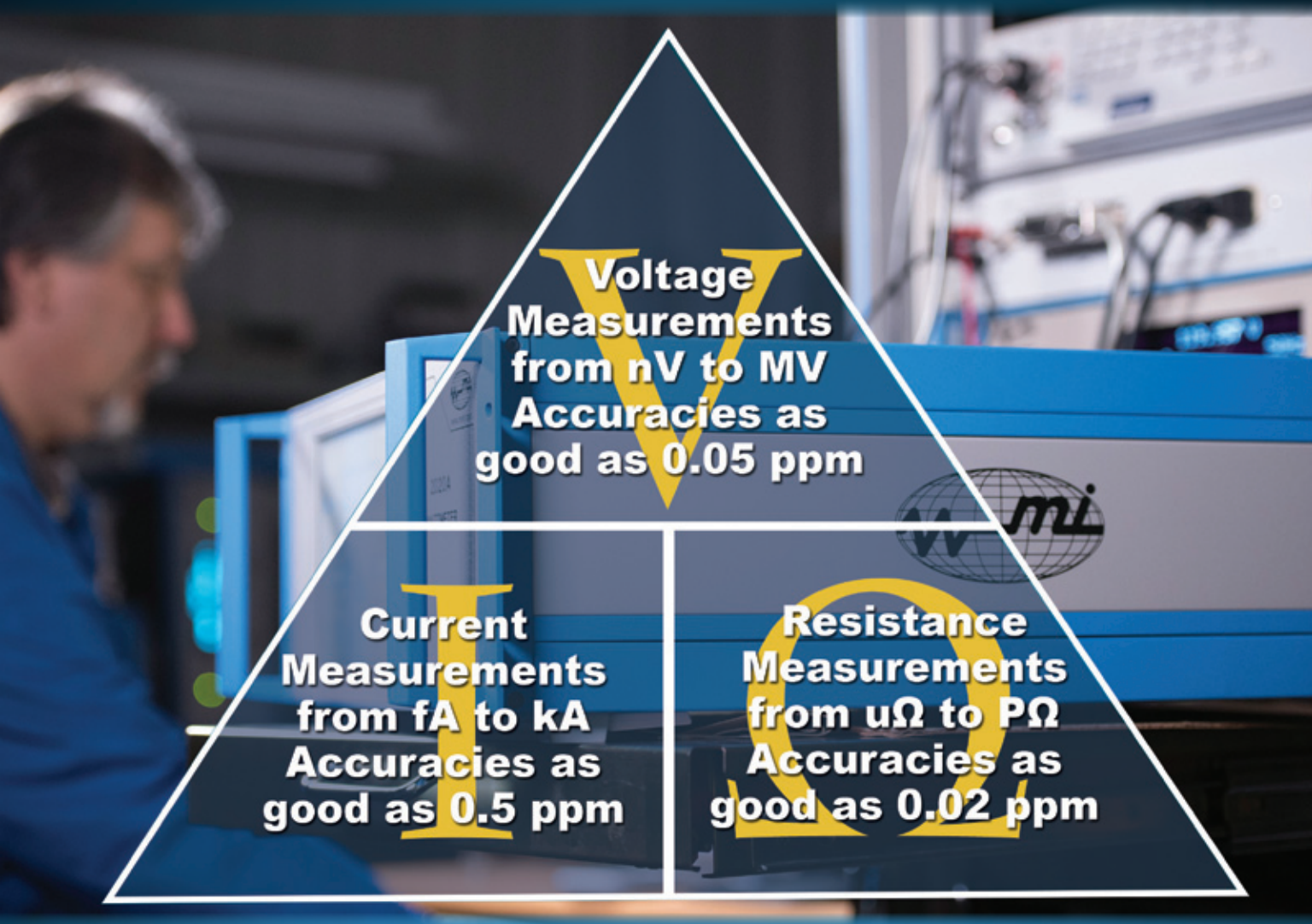
JULY 10-15, 2016 • OTTAWA, CANADA

This biennial conference is the premier international forum for the exchange of information on electromagnetic measurements at the highest accuracy levels.

www.cpem2016.com

Measurements International

Metrology is Our Science, Accuracy is Our Business™



MEASUREMENTS IS NOT JUST OUR NAME, ...IT IS OUR PASSION

Let MI help with your measurement passions too. Learn how we can team with you in both measurement and accreditation.

Measurements International has been extending the limits of electrical metrology performance for nearly 30 years. We can help you achieve the better measurement practices that your goals and quality systems need.

Contact MI, the preferred supplier of instrumentation and standards for DC and Temperature metrology as well as solutions for the AC Power industry.

www.mintl.com • sales@mintl.com