CAL LAB

THE INTERNATIONAL JOURNAL OF METROLOGY

2014
JULY
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1 mW Power Sensor Calibration with Vector Mismatch Corrections Based on the Direct Comparison Method

Analyzing the Effects of Reducing the Ending Zero Vs. Ignoring the Trailing Zero on Measuring Instruments Used for Force Calibration

Documentation & Document Control

Report of an Interlaboratory Comparison of Phase Noise on a Fluke 9640A-LPN

Electric Current Measurement

DANISENSE

DS Series Current Transducers

±300A to ±3000A, 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

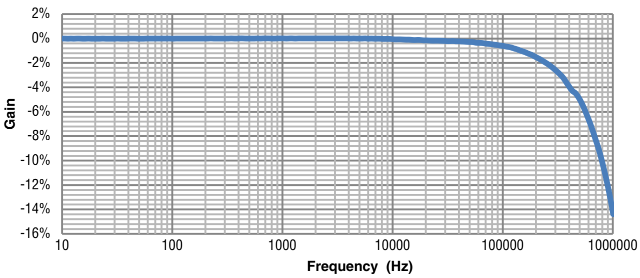
	DS200	DS600	DS2000
Primary Current, rms	200A	600A	2000A
Primary Current, Peak	±300A	±900A	±3000A
Turns Ratio	500:1	1500:1	1500:1
Output Signal (rms/Peak)	0.4A/±0.6A†	0.4A/±0.6A†	1.33A/±2A†
Overall Accuracy	0.01%	0.01%	0.01%
Offset	<20ppm	<10ppm	<10ppm
Linearity	<1ppm	<1ppm	<1ppm
Operating Temperature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

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

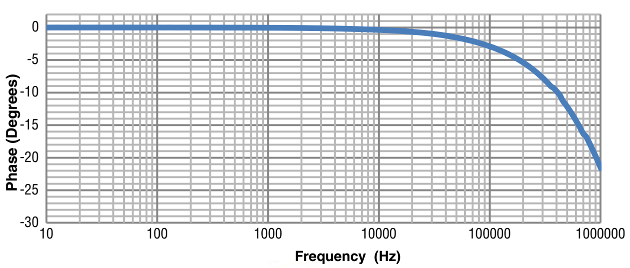
† Voltage Output options available in ±1V and ±10V

Gain / Phase

Gain (DS200, typical)



Phase (DS200, typical)



DSSIU-4 for Multi Channel Systems

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

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

DSSIU-4

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FEATURES

DEPARTMENTS

ON THE COVER: C-Series Laser Laboratory Optical Table Station at the Air Force Primary Standards Laboratory in Heath, Ohio. Steve Comisford, an Engineering Technician with Bionetics Corp., sets up a Silicon Trap Detector Working Standard in front of a C-Series Primary Reference Standard Calorimeter, in preparation for measuring a customer's Laser Power instrument.

CALENDAR

CONFERENCES & MEETINGS 2014

Aug 24-29 CPEM 2014. Rio de Janeiro, Brazil. Conference on Precision Electromagnetic Measurements. http://www2.inmetro.gov.br/cpem2014/

Sep 3-5 11th Symposium on Laser Metrology for Precision Measurement and Inspection Industry (LMPMI). Tsukuba, Japan. http://lmpmi2014.jp/.

Sep 15-17 20th IMEKO TC-4 Symposium and Workshop. Benevento, Italy. 20th IMEKO TC-4 Symposium on Measurements of Electrical Quantities and the 18th TC-4 Workshop on ADC and DAC Modeling and Testing. http://www.imeko-tc4-2014.org/.

Sep 15-18 IEEE AUTOTESTCON 2014 – 50th Anniversary. St. Louis, MI. www.ieee-autotest.com

Sep 23-24 IMEKO TC-19 Symposium on Environmental Instrumentation and Measurement. Chemnitz, Germany. http://www.tu-chemnitz.de/etit/messtech/imeko/.

Sep 29-Oct 1 Test & Measurement Conference & Workshop. Gauteng, South Africa. Held at the Misty Hills Conference Hotel at Muldersdrift. http://www.home.nla.org.za/.

Nov 6-8 India Lab Expo. Hyderabad, India. 6th International Exhibition & Conference on Lab, Analytical & Biotechnology Instruments. http://www.indialabexpo.com/

Nov 9-14 The 29th ASPE Annual Meeting. Boston, MA. The 2014 American Society for Precision Engineering Annual Meeting will provide a forum for presentation and discussion of the latest technical information and achievements in precision engineering. http://www.aspe.net.

Nov 19-20 Large Volume Metrology Conference & Exhibition (LVMC). Manchester, United Kingdom. The LVMC is the only European event solely dedicated to portable and large volume 3D measurement technology. It is the premier technical conference in Europe dedicated solely to the use of precision dimensional measurement technology for process improvement for manufacturers. http://www.lvmc.eu/.

Dec 2-5 84th ARFTG Microwave Measurement Conference. Boulder, CO. "The New Frontiers for Microwave Measurements" is this conference's theme. They encourage submission of original papers exploring all areas of microwave, RF, and mm-wave measurements. http://www.arftg.org/.

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EDITOR'S DESK

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Leveraging Data

I was tying up tomato vines in the backyard, earlier this summer, when a large aircraft slowly flew overhead. We live in close proximity to the third busiest airport in the country, as well as an Air Force base, so it's pretty normal to have large aircraft whizzing by high in the air. But looking at the back-end of this particular plane flying low in the sky, I could tell this wasn't the usual flyby.

The local news confirmed my thoughts. This particular flight was part of a project conducted by the National Center for Atmospheric Research, partnered with NASA and the EPA, to study the high levels of ozone at different altitudes as air patterns circulate up and down the Colorado Front Range in the Denver Metropolitan area. The state currently monitors high levels of air pollution in the summer-time (think crude oil refineries, natural gas frackers, and mega feed lots), but this National Science Foundation's (NSF) research aircraft (a Lockheed C-130 Hercules) is part of a larger study called Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality (DISCOVER-AQ), which aims to improve satellites' ability to monitor air quality here on earth.

Other similar, environmental data collection studies are the Arctic Radiation IceBridge Sea and Ice Experiment (ARISE) by NASA, the HIAPER Pole-to-Pole Observation (HIPPO) project, the Indian Ocean Experiment (INDOEX) project, and Long-Term Ecological Research (LTER) conducted by the NSF. Studies, like the latter project, compile data to help farmers determine exactly how much fertilizer to apply to which crop, in which field, via GPS. It took creative data crunchers to come up with effective solutions to a problem—in this case, excessive nitrogen runoff and the release of greenhouse gas (nitrous oxide).

Internet businesses like Yahoo! and Facebook also collect data, in the form of our clicks and then take that information to make predictions on user behavior. Progressive Insurance devised their "Snapshot" device in order to monitor driver behavior. These different industries (non-profit, insurance, and internet) may have different objectives, but they all collect data with the objective to mine it of something valuable. We all know data is valuable, but it takes creativity to come up with a plan—such as new tools & technologies or finding new ways to use data. Mike, our publisher, explores this vein of thought, and how it could apply to the calibration lab, in this issue's "Automation Corner."

Our other contributors for this issue are: Ken Parson, continuing with his series on lab management titled "Documentation & Document Control"; Bart Caswell with his "Report of an Interlaboratory Comparison of Phase Noise on a Fluke 9640-LPN Signal Generator"; and Henry Zumbrun of Morehouse Instrument Company, who has shared his expertise on "Analyzing the Effects of Reducing the Ending Zero Vs. Ignoring the Trailing Zero on Measuring Instruments Used for Force Calibration."

We are very appreciative to have knowledgeable members of our industry take time to share their wisdom with us. Another form of "leveraging data" is passing on the time-worn knowledge to the next generation of engineers and technicians.

Happy Measuring,

Sita

CALENDAR

SEMINARS: Online & Independent Study

ASQ CCT (Certified Calibration Technician) Exam Preparation Program. Learning Measure. http://www.learningmeasure.com/.

AC-DC Metrology– Self-Paced Online Training. Fluke Training. http://us.flukecal.com/training/courses.

Basic Measurement Concepts Program. Learning Measure. http://www.learningmeasure.com/.

Basic Measuring Tools – Self Directed Learning. The QC Group, http://www.qcgroup.com/sdl/.

Basic RF and Microwave Program. Learning Measure. http://www.learningmeasure.com/.

Certified Calibration Technician – Self-study Course. J&G Technology. http://www.jg-technology.com/selfstudy.html.

Introduction to Measurement and Calibration – Online Training. The QC Group, http://www.qcgroup.com/online/.

Introduction to Measurement and Calibration – Self-Paced Online Classes. Fluke Calibration. http://www.flukecal.com/training.

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

Measurement Uncertainty – Self-Paced Online Training. Fluke Training. http://us.flukecal.com/training/courses.

Measurement Uncertainty Analysis – Online Training. The QC Group, http://www.qcgroup.com/online/.

Metrology for Cal Lab Personnel– Self-Paced Online Training. Fluke Training. http://us.flukecal.com/training/courses.

Metrology Concepts. QUAMETEC Institute of Measurement Technology. http://www.QIMTonline.com.

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

Precision Electrical Measurement – Self-Paced Online Training. Fluke Training. http://us.flukecal.com/training/courses.

Vibration and Shock Testing. Equipment Reliability Institute, http://www.equipment-reliability.com/distance_learning.html.

SEMINARS: Dimensional

Sept 8-9, 2014 Hands-On Gage Calibration and Repair Workshop. Atlanta, GA. IICT Enterprises. http://www.iictenterprisesllc.com/.

Sep 30-Oct 2, 2014 Hands-on Gage Calibration. Aurora, IL. Mitutoyo Institute of Metrology. http://www.mitutoyo.com/support/mitutoyo-institute-of-metrology/.

Oct 6-7, 2014 Hands-On Gage Calibration and Repair Workshop. Austin, TX. IICT Enterprises. http://www.iictenterprisesllc.com/.

Oct 21-22, 2014 Hands-On Gage Calibration and Repair Workshop. Eau Claire, WI. IICT Enterprises LLC. http://www.iictenterprisesllc.com/.

Nov 4-6, 2014 Hands-on Gage Calibration. Aurora, IL. Mitutoyo Institute of Metrology. http://www.mitutoyo.com/support/mitutoyo-institute-of-metrology/.

SEMINARS: Electrical

Sep 8-11, 2014 MET-101 Basic Hands-on Metrology. Everett, WA. Fluke Calibration. http://us.flukecal.com/training/courses/MET-101.

Sep 15-17, 2014 Instrumentation for Test and Measurement. Las Vegas, NV. Technology Training, Inc. http://www.ttiedu.com

Oct 21-23, 2014 MET-302 Introduction to Measurement Uncertainty. Everett, WA. Fluke Calibration. http://us.flukecal.com/training/courses/MET-302.

Oct 27-30, 2014 MET-101 Basic Hands-on Metrology. Everett, WA. Fluke Calibration. http://us.flukecal.com/training/courses/MET-101.

Nov 17-20, 2014 MET-301 Advanced Hands-on Metrology. Seattle, WA. Fluke Calibration. http://us.flukecal.com/training/courses/MET-301.

SEMINARS: Flow & Pressure

Sep 9-11, 2014 Fundamentals of Flow Measurement Training Course. Loveland, CO. Colorado Engineering Experiment Station Inc. (CEESI) http://www.ceesi.com.

Sep 15-19, 2014 Comprehensive Flow Measurement Training Course. Loveland, CO. Colorado Engineering Experiment Station Inc. (CEESI) http://www.ceesi.com.

CALENDAR

Sep 22-26, 2014 Principles of Pressure Calibration. Phoenix, AZ. Fluke Calibration. http://us.flukecal.com/Principles-of-Pressure.

Sep 24-26, 2014 Flow Measurement and Calibration. Munich, Germany. TrigasFI GmbH. http://www.trigasfi.de/html/en_seminars.htm.

Oct 6-10, 2014 Advanced Piston Gauge Metrology. Phoenix, AZ. Fluke Calibration. http://us.flukecal.com/training.

Nov 25-27, 2014 Principles and Practice of Flow Measurement Training Course. East Kilbride, United Kingdom. http://www.tuvnel.com/tuvnel/courses_workshops_seminars/.

Nov 17-21, 2014 Principles of Pressure Calibration. Phoenix, AZ. Fluke Calibration. http://us.flukecal.com/Principles-of-Pressure.

SEMINARS: General & Management

Sep 11-12 Metrology Concepts. Las Vegas, NV. Technology Training, Inc. http://www.ttiedu.com.

Oct 22-24, 2014 Cal Lab Management; Beyond 17025 Training. Boca Raton, FL. WorkPlace Training. http://www.wptraining.com.

Oct 27-28, 2014 Cal Lab Benchmark Challenge: Hands on Electrical, Temperature, Pressure. Boca Raton, FL. WorkPlace Training http://www.wptraining.com.

Nov 3-6, 2014 Effective Cal Lab Management. Everett, WA. Fluke Calibration. http://us.flukecal.com/lab_management_training.

Nov 3-7, 2014 Fundamentals of Metrology. Gaithersburg, MD. http://www.nist.gov/pml/wmd/labmetrology/training.cfm.

Dec 9-11, 2014 Cal Lab Management; Beyond 17025 Training. Los Angeles, CA. WorkPlace Training. http://www.wptraining.com.

SEMINARS: Mass

Sep 8-19, 2014 Mass Metrology Seminar. Gaithersburg, MD. NIST / Office of Weights and Measures. http://www.nist.gov/pml/wmd/labmetrology/training.cfm.

SEMINARS: Measurement Uncertainty

Sep 9, 2014 Introduction to Measurement Uncertainty Training. Aberdeen, UK. http://www.tuvnel.com/tuvnel/courses_workshops_seminars/.

Sep 22-24, 2014 Measurement Uncertainty Training Course. Loveland, CO. Colorado Engineering Experiment Station Inc. (CEESI) http://www.ceesi.com.

Oct 1-2, 2014 Measurement Uncertainty (per ILAC P14 Guidelines). Chicago, IL. WorkPlace Training http://www.wptraining.com.

Oct 21-23, 2014 Measurement Uncertainty Workshop. Fenton, MI. QUAMETEC Institute of Measurement Technology. To register call: (810) 225-8588. http://www.QIMTonline.com.

Oct 30-31, 2014 Measurement Uncertainty (per ILAC P14 Guidelines). Boca Raton, FL. WorkPlace Training http://www.wptraining.com.

SEMINARS: Temperature

Sep 9-11, 2014 Advanced Topics in Temperature Metrology. American Fork, UT. Fluke Calibration. http://us.flukecal.com/training/courses/Principles-Temperature-Metrology.

Oct 14-16, 2014 Principles of Temperature Metrology. American Fork, UT. Fluke Calibration. http://us.flukecal.com/training/courses/Principles-Temperature-Metrology.

SEMINARS: Vibration

Oct 1, 2014 Vibration Technology Training. Silver Spring, MD (Washington, DC Area). Free, half-day seminar. For more info visit: http://www.modalshop.com/calibration.asp?ID=992 .

Nov 4-6, 2014 Fundamentals of Random Vibration and Shock Testing, HALT, ESS, HASS (...). Huntsville, AL. http://www.equipment-reliability.com.

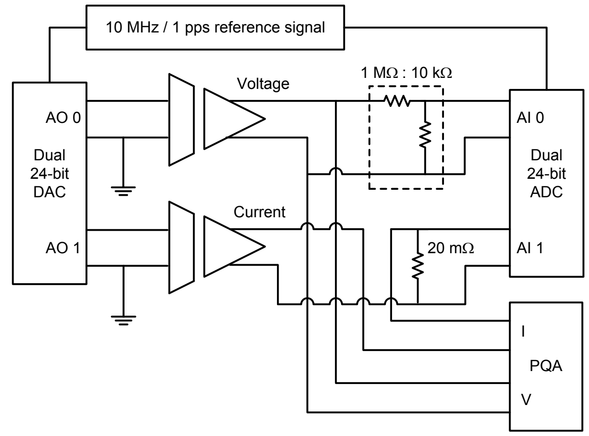
Nov 10-13, 2014 Fixture Design for Vibration and Shock Testing. Las Vegas, NV. http://www.ttiedu.com/schedule.html.

Visit **www.callabmag.com** for upcoming and future events!

VSL Develops New Calibration and Test Facility for Power Quality Parameters

A new facility has been developed at VSL, the Dutch Metrology Institute, to calibrate and test single or three-phase power analyzers and calibrators for power quality (PQ) parameters such as frequency, time base, voltage, current, power with arbitrary phase angle, harmonics and THD for voltage and current, voltage dips and swells, voltage fluctuations (flicker), and unbalance. The new sampling system allows for flexibility in the PQ signals to be generated, and in how to analyze them. Control and analysis software has been written to generate the signals and to analyze the measurement results in full accordance with the relevant standards, in particular the IEC 61000-4-30. Hence, in order to have reliable and comparable results, the PQ parameters are determined in the same way as the device under test does. Consequently, the aim is not necessarily the lowest possible calibration uncertainty, but the most valuable calibration result for the customer instead.

For several parameters the PQ analyzer under test can be verified to operate conform written standards such as the IEC 61000-3-3, 61000-4-30, and the EN 50160. For example, instantaneous, short-term and long-term flicker severity can be tested with square or sinusoidal modulation, for signals with or without harmonic distortion. Another example is the 1.5 s time constant of the internal filter that can be tested by measuring the response to a step change in the harmonic distortion of the mains signal. In all cases, test measurements and calibration parameters can be configured in agreement with the customer.



Schematic diagram of the VSL reference setup used to calibrate a PQ analyzer. Traceability is obtained by calibration of the resistive divider, the shunt resistor, and the analog-to-digital converters (ADCs).

For more information on this topic, please contact Helko van den Brom (hvdbrom@vsl.nl).

Fill 'er Up: NIST Develops Prototype Meter Test for Hydrogen Refueling Stations

To support the fair sale of gaseous hydrogen as a vehicle fuel, researchers at the National Institute of Standards and Technology (NIST) have developed a prototype field test standard to test the accuracy of hydrogen fuel dispensers. Once the standard is field tested, it will serve as a model for constructing similar devices for state weights and measures inspectors to use.

Three automakers plan to begin selling hydrogen-fueled vehicles to consumers in 2015. The state of California has opened nine refueling stations and is funding the construction of an additional 28 hydrogen stations during the next few years to service the growing number of hydrogen fuel cell vehicles on their roads.

NIST Handbook 44, the bedrock reference text for weights and measures inspectors, includes specifications, tolerances and other requirements for commercial weighing and measuring equipment ranging from gasoline dispensers to grocery store scales. Handbook 44, which has been adopted by all states, stipulates that hydrogen will be sold by the kilogram, and according to Juana Williams, a NIST weights and measures expert, hydrogen-dispensing pumps must be accurate to within 2 percent, or 20 grams, per kilogram.

"It's much more difficult to measure hydrogen gas delivered at 5,000 to 10,000 psi than it is to measure a product that is a liquid at atmospheric temperatures and pressures," says Williams. "While a kilogram of hydrogen has approximately the same energy content as a gallon of gasoline, the allowable error is slightly less stringent than for gasoline."

Even with the larger allowance, some have suggested these tolerances are too tight and proposed alternatives as high as 10 or 20 percent. What isn't clear is whether these claims arise because the meters are unable to perform within the tolerance specified in Handbook 44 or if the equipment and methods used to conduct testing are contributing larger errors to the process.

"We've shown that the master meter in our lab is capable of dispensing helium from a simulated hydrogen dispenser with errors of 1 percent or less," says NIST's Jodie Pope, who designed the field testing apparatus. "So we can extrapolate that it is possible to measure hydrogen with accuracy sufficient for a fair marketplace."

The next challenge is to determine what accuracy is achievable in field installations of hydrogen dispensing systems when using NIST traceable standards and well-defined test equipment and test procedures and to then translate this into guidance for use by weights and measures inspectors and industry.

Source: *NIST Tech Beat – July 29, 2014 (http://www.nist.gov/public_affairs/tech-beat/tb20140729.cfm#hydrogen_meter).*

Snowballs to Soot: The Clumping Density of Many Things Seems to Be a Standard

Particles of soot floating through the air and comets hurtling through space have at least one thing in common: 0.36. That, reports a research group at the National Institute of Standards and Technology (NIST), is the measure of how dense they will get under normal conditions, and it's a value that seems to be constant for similar aggregates across an impressively wide size range from nanometers to tens of meters.

NIST hopes the results will help in the development of future measurement standards to aid climate researchers and others who need to measure and understand the behavior of aerosols like carbon soot in the atmosphere.

Soot comes mostly from combustion and is considered the second biggest driver of global warming, according to NIST chemist Christopher Zangmeister. It is made up of small round particles of carbon about 10 or 20 nanometers across. The particles stick together randomly in short chains and clumps of a half dozen or more spheres. These, in turn, clump loosely together to form larger, loose aggregates of 10 or more which over a few hours will compact into a somewhat tighter ball which is atmospheric soot.

The interesting question for chemists studying carbon aerosols is how tight? How dense? Among other things, the answer relates to the balance of climate effects from soot: heating from light absorption versus cooling from light reflection.

The maximum packing density of objects is a classic problem in mathematics, which has been fully solved for only the simplest cases. The assumed density in models of atmospheric soot is 0.74, which is the maximum packing density of perfect spheres, such as billiard balls, in a given space. But when Zangmeister's team made measurements of the packing density of actual soot particles, the figure they got was 0.36.

Enter the summer help. Two students, one in college and one in high school, who were working with Zangmeister's group last summer were set to the task of modeling the packing question with little 6 mm plastic spheres sold for pellet guns. They glued thousands of random combinations of spheres together in clumps of from 1 to 12 spheres, and then filled every available size of graduated cylinders and hollow spheres with their assemblies, over and over, and over.

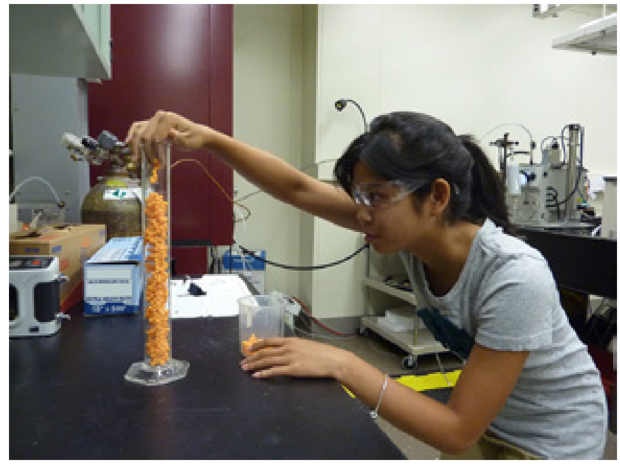
Their charted results, as a function of clump size, form a curve that levels off at … 0.36.

It gets better. Inspired by a book on the solar system he was reading with his son, Zangmeister checked NASA's literature. Comets are formed very much the same way as soot particles, except out of dust and ice, and they're a lot bigger. NASA's measurements on a collection of 20 comets estimate that packing density at between 0.2 and 0.4. So 0.36 may be an all-purpose value.

NIST's interest in the nature of soot particles is driven by a desire to imitate them, according to Zangmeister. "It's amazing how much uncertainty there is in optical measurements of particles in the atmosphere. The reason for this uncertainty is rooted in something really important to NIST: there are no real methods for calibrations. You can calibrate any CO_2 measurement using one of our Standard Reference Materials for CO_2 in air, but there's no such thing as a bottle of standard aerosol or a standard aerosol generator. That's really at the heart of what we're trying to do: make a black material that simulates carbon that you can put into an aerosol and know it will come out the same way every time. It's a real materials chemistry project."

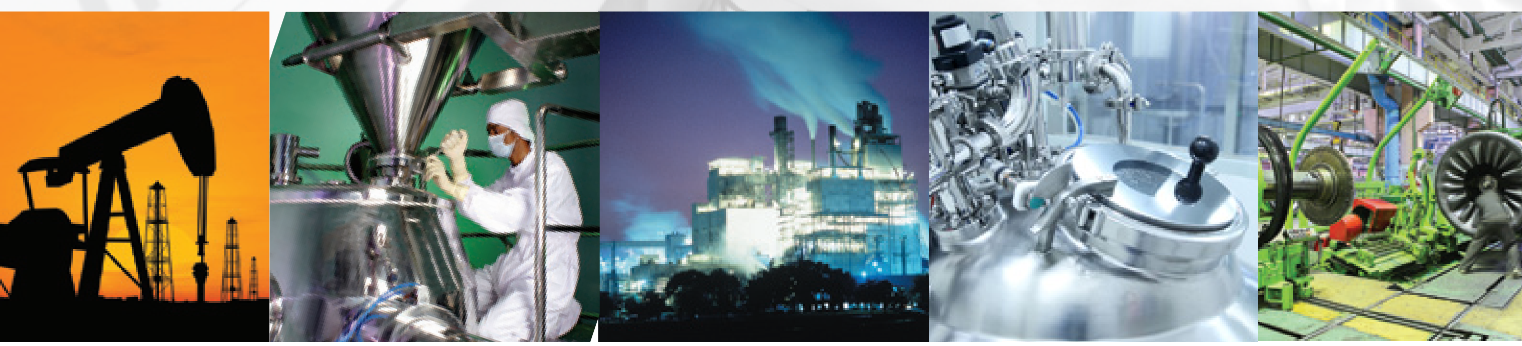
The agency is working with the National Research Council of Canada and Environment Canada on the project.

Source: *NIST Tech Beat for June 17, 2014 (http://www.nist.gov/public_affairs/tech-beat/ or http://www.nist.gov/mml/csd/density-061014.cfm).*



High school student Jessica Young checking the packing density of random aggregates of plastic spheres in a cylinder. Young's work as a summer intern at NIST contributed to a paper arguing that rigid aggregates like those she's testing tend to clump together at roughly the same density regardless of scale, from microscopic soot to large comets. (Credit: Baum/NIST)

Have Confidence in your Measurements…



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'Comb on a Chip' Powers New NIST/Caltech Atomic Clock Design

Researchers from the National Institute of Standards and Technology (NIST) and California Institute of Technology (Caltech) have demonstrated a new design for an atomic clock that is based on a chip-scale frequency comb, or a microcomb.

The microcomb clock, featured on the cover of the inaugural issue of the new journal *Optica*, is the first demonstration of all-optical control of the microcomb, and its accurate conversion of optical frequencies to lower microwave frequencies. (Optical frequencies are too high to count; microwave frequencies can be counted with electronics.)

The new clock architecture might eventually be used to make portable tools for calibrating frequencies of advanced telecommunications systems or providing microwave signals to boost stability and resolution in radar, navigation and scientific instruments. The technology also has potential to combine good timekeeping precision with very small size. The comb clock might be a component of future "NIST on a chip" technologies offering multiple measurement methods and standards in a portable form.

Frequency combs produce precisely defined colors, or frequencies, of light that are evenly spaced throughout the comb's range. (The name comes from the spectrum's resemblance to the teeth of a pocket comb.) The original combs required relatively large lasers that produced rapid, extremely short pulses of light, but more recently NIST and other laboratories have developed much smaller microcombs.

A microcomb generates its set of frequencies from light that gets trapped in the periphery of a tiny silica glass disk, looping around and around the perimeter. These combs can be astonishingly stable. NIST has an ongoing collaboration in this area with Caltech researchers, who made the 2-millimeter-wide silica disk that generates the frequency comb for the new clock.

The new microcomb clock uses a laser to excite the Caltech disk to generate a frequency comb, broadens the spectrum using nonlinear fiber, and stabilizes two comb teeth (individual frequencies) to energy transitions in rubidium atoms that "tick" at optical frequencies. (Conventional rubidium atomic clocks operate at much lower microwave frequencies.) The comb converts these optical frequency ticks to the microwave domain.

Thanks to the gear-like properties of the disk and the comb, the output is also 100 times more stable than the intrinsic ticking of the rubidium atoms.

The center of the comb spectrum is locked to an infrared laser operating at 1560 nanometers, a wavelength used in telecommunications.

NIST researchers have not yet systematically analyzed the microcomb clock's precision. The prototype uses a tabletop-sized rubidium reference. The scientists expect to reduce the instrument size by switching to a miniature container of atoms like that used in NIST's original chip-scale atomic clock. Scientists also hope to find a more stable atomic reference.

The microcomb chip was made by use of conventional semiconductor fabrication techniques and, therefore, could be mass produced and integrated with other chip-scale components such as lasers and atomic references. NIST researchers expect that, with further research, the microcomb clock architecture can achieve substantially better performance in the future.

The research is supported in part by the Defense Advanced Research Projects Agency and National Aeronautics and Space Administration.

Source: *NIST Tech Beat - July 29, 2014 (http://www.nist.gov/public_affairs/tech-beat/tb20140729.cfm#comb)*

HAMEG Instruments Products Now an Integral Part of the Rohde & Schwarz Portfolio

T&M products from Rohde & Schwarz subsidiary HAMEG Instruments will now be marketed under the Rohde & Schwarz logo. The well-known brand name will help improve the international position of the economical, general-purpose T&M instruments from HAMEG, which are part of the joint Value Instruments portfolio.

Previously, all HAMEG products had a dual logo that included the company names Rohde & Schwarz and HAMEG. According to Roland Steffen, Executive Vice President and Head of the Test and Measurement Division, "In recent years, HAMEG has grown rapidly in Europe. Now we want to expand this growth to other regions. The best way for this to succeed is with the Rohde & Schwarz brand, which enjoys an outstanding reputation worldwide. This strategy clearly sets us apart from other suppliers."

Using the Rohde & Schwarz logo is also the logical continuation of the Value Instruments initiative, where the two companies' portfolios of reliable precision instruments in the entry-level price segment are marketed together under the Value Instruments label. André Vander Stichelen, Managing Director of HAMEG Instruments, elaborates, "By changing the logo, we want to underscore the common bond between the two companies. The strategic focus of HAMEG will not change. We will continue to offer affordable, optimum performance T&M equipment."

The company HAMEG Instruments GmbH will continue to operate as an independent company under the umbrella of the Rohde & Schwarz group of companies. The two sites in Mainhausen and Chemnitz will be expanded.

For more information: http://value.rohde-schwarz.com.

Trescal Acquisitions in US and Italy

Trescal, the international specialist in calibration services, announced on June 30th, 2014 the acquisition of US company Master Metrology, Inc. and Gefran's Italian metrology assets. Respectively based in Towson (Maryland, USA) and Provaglio d'Iseo (Italy) and A2LA and Accredia accredited.

With an annual turnover of $2 million and 16 employees including 7 engineers, Master Metrology increases Trescal's growing presence in the US and also broadens its technical offer, notably in the dimensional and torque domains.

Gefran's Italian metrology laboratory, with annual sales of €800,000 and 5 employees including 4 engineers, will be merged with Trescal's existing laboratory in Brescia, growing its lab-based offer in Italy's humidity, temperature and climatic chamber calibration sector, within laboratory and on site.

The deals were completed with the support of Trescal's majority shareholder, Ardian, the premium independent private investment company. They are the fifth and the sixth build-up transactions executed following Ardian's acquisition of Trescal in July 2013.

Exova Metech Acquires Raufoss Offshore Calibration

Exova Metech, the calibration and metrology division of Exova, the global testing, calibration and advisory services provider, has acquired the specialist calibration business of Raufoss Offshore in Norway.

The move will see the transfer of technology assets and seven skilled personnel to Exova Metech, with operations remaining in their current facility in Raufoss Industrial Park, north of Oslo.

Raufoss Offshore provides calibration services to customers in the oil & gas, defence, transportation and engineering sectors throughout Norway. As part of the deal, Exova Metech will also take on the provision of calibration services to divisions within Raufoss Offshore itself.

Hans Åberg, managing director of Exova Metech, comments: "Raufoss Offshore Calibration is an excellent addition to the technically demanding services we already provide to customers throughout Europe and US. We are now well placed to extend our range of capabilities and the number of customers we can support. I am delighted to welcome the new team to Exova.

Exova Metech is headquartered in Sweden and employs more than 330 personnel in 21 locations including Sweden, Denmark, Finland, Germany, Czech Republic and US, serving customers in sectors including energy, aerospace, defence, telecom, general engineering, life science and transportation. www.exovametech.com.

GTCR Completes Acquisition of Cole-Parmer

GTCR, a leading private equity firm, announced that it has completed the previously announced acquisition of Cole-Parmer Instrument Company ("Cole-Parmer" or the "Business") from Thermo Fisher Scientific Inc. (NYSE: TMO) ("Thermo Fisher"). Cole-Parmer, headquartered in

CAL-TOONS by Ted Green teddytoons@verizon.net

IT WAS THE VERY LAST TIME A FREQUENCY COUNTER WAS INVITED TO PLAY POKER.

Vernon Hills, Illinois, is a leading global manufacturer and distributor of specialty laboratory equipment, instruments and supplies to a diverse range of customers in pharmaceutical, biotech, healthcare, chemicals, food and other research-based or regulated markets. GTCR is partnering with life science industry veteran Bernd Brust to carve-out the business from Thermo Fisher and position the Business for future growth.

Founded in 1955, Cole-Parmer offers a portfolio of industry-leading proprietary brands and private-label products in niche applications to fulfill important needs in the laboratory market. The business has deep technical expertise across a range of specialty products in the field of fluid handling, test & measurement, electrochemistry and other laboratory products. Cole-Parmer sells its broad portfolio of products to a diverse, global customer base.

The investment is a result of GTCR's proactive efforts with Mr. Brust targeting the medical and laboratory product industries. Mr. Brust, former CEO of Qualicaps and, previously, Chief Commercial Operations Officer of Life Technologies Corporation (acquired by Thermo Fisher in 2014), will become the CEO of the Business as a part of the transaction. Mr. Brust has an extensive track record of success within the healthcare and life sciences industry.

"I am excited to partner with GTCR on this opportunity," stated Mr. Brust. "Cole-Parmer represents a compelling platform that is well-known within the scientific research and life sciences communities. I look forward to working with the existing Cole-Parmer management team to grow the Business through product development and acquisitions to extend its leadership position."

GTCR's investment in Cole-Parmer was funded from GTCR Fund XI, a private equity fund raised in 2014 with $3.85 billion of limited partner equity capital commitments. Credit Suisse and Goldman Sachs provided financing for the transaction. Kirkland & Ellis LLP served as legal counsel to GTCR.

Keysight Technologies Begins Operations

Keysight Technologies, Inc. announced *Aug. 1, 2014* the electronic measurement business of Agilent Technologies has begun operating under the Keysight name. It will remain a wholly owned subsidiary of Agilent Technologies until early November when the separation is expected to be completed and Keysight begins trading on the NYSE under the symbol KEYS.

Keysight is a market leader holding the number one position in its industry segments of communications; aerospace and defense; and industrial, computers, and semiconductors. Keysight's separation from Agilent was announced in September 2013.

"As we launch our new company, we are mindful of our rich heritage as part of Agilent and prior to that, Hewlett-Packard," said Ron Nersesian, Keysight president and CEO. "We are also mindful of our responsibility and commitment to our stakeholders including customers, our shareholders and our employees. We look forward to the many opportunities ahead that will allow us to focus solely on electronic measurement and showcase the leading-edge technologies that our customers have come to expect."

Information about Keysight is available at www.keysight.com.

1 mW Power Sensor Calibration with Vector Mismatch Corrections Based on the Direct Comparison Method

Michael L. Schwartz
Cal Lab Solutions, Inc.

Many calibration labs are starting to calibrate power sensors or looking to increase their capabilities and frequency range. In this “Metrology 101” we hope to help some calibration labs improve their measurement technique, as well as accuracy and quality of their power sensor calibration product. This test methodology has been used by many labs for several years.

Introduction

The calibration factor of a power sensor is a measure of its ability to measure power at a given frequency. The power sensors’ efficiency is usually given as a percentage (%) representing its ability to convert the incident power to an accurately-representative reading on the power meter. A power sensor with a calibration factor of 100% would convert 100% of the power incident on it into an indicated value. Calibration factor is a combination of the effective efficiency and the mismatch loss of the sensor.

Test Description

The direct comparison method (also known as the buried sensor method) has been proven to be a very cost effective, accurate and repeatable methodology to calibrate the frequency response/calibration factors up to 50 GHz. This method requires the operator to characterize the output port of the power splitter using a standard power sensor with at National Metrology Institute (NMI) Traceable calibration. Once the system has been characterized, it can then be verified with another known power sensor. Then, after the system has been verified, DUT power sensors can then be calibrated.

Test Process

System Calibration

1. Use Figure 1 to set up equipment for system calibration.
2. Preset all test equipment.
3. Zero and calibrate the REFERENCE sensor on the N1914A power meter (Chan B).
4. Set the cal factor for the REFERENCE sensor to 100%.
5. Connect the REFERENCE sensor to the REF arm of the power splitter (typically Port 3).
6. Set the calibration factor for the STANDARD sensor to its 50 MHz value.
7. Connect the STANDARD power sensor to the N1914A power meter (Chan A).
8. Zero and calibrate the STANDARD power sensor.
9. Connect the STANDARD sensor to the TEST arm of the power splitter (typically Port 2).
10. Set the source frequency to the first (next) test frequency in Table 1.
11. Set the appropriate cal factor vs. frequency for the STANDARD Sensor.
12. Adjust the source output power so that the STANDARD power sensor reads: 1 +/- 0.02 mW. Note: Small leveling errors will be mathematically compensated in the equations.

Equipment Required		
Instrument	**Critical Specifications**	**Recommended Model**
Synthesized Sweeper	Frequency: 10 MHz to 50GHz	Agilent PSG
Power Meter	Power Meter Dual Channel	Agilent N1924A
Power Splitter **Reference Sensor** **Standard Sensor** **Verification Sensor**	50 MHz to 50 GHz 50 MHz to 50 GHz /-30 dBm to +20 dBm 50 MHz to 50 GHz /-30 dBm to +20 dBm 50 MHz to 50 GHz /-30 dBm to +20 dBm	Agilent 11667C-H04 Agilent N8487A Agilent N8487A-H84 Agilent N 8487A-H84

Freq (GHz)	P_{STD} Chan A	P_{REF} Chan B	$P_{S\Delta}$ $P_{STD} - P_{REF}$	P_{VER} Chan A	P_{REF} Chan B	$P_{V\Delta}$ $P_{VER} - P_{REF}$	Station Ver $P_{V\Delta} - P_{S\Delta}$ *100
0.050	1.010	0.939	0.070	1.008	0.944	0.064	0.63 %
1.0							
1 GHz Steps							
50							

Table 1.

Freq (GHz)	P_{STD} Chan A	$P_{REF-STD}$ Chan B	P_{DUT} Chan A	$P_{REF-DUT}$ Chan B	STD Mag	STD Phase	DUT Mag	DUT Phase	SPLT Mag	SPLT Phase
0.050	1.010	0.939	0.995	0.939	0.12	35°	0.13	37°	0.15	71°
1.0										
1 GHz Steps										
50										

Table 2.

13. Record the indicated power level (in mW) of Chan A and Chan B in Table 1.
14. Compute the difference (in mW): Save the value in Table 1.
15. Repeat steps 10 through 14 for the remaining frequencies in Table 1.

System Verification (optional)

16. Do not disturb or disconnect the REFERENCE sensor. Leave it connected to the REF arm of the power splitter
17. Connect the verification power sensor to the N1914A power meter (Chan A).
18. Zero and calibrate the verification power sensor.
19. Repeat steps 10 through 14 above with the VERIFICATION sensor in place of the STANDARD sensor.
20. Calculate frequency by frequency the percentage of error between the STANDARD data and the VERIFICATION data. At each frequency point, the error must be <1%.

DUT Measurement

21. Do not disturb or disconnect the REFERENCE sensor. Leave it connected to the REF arm of the power splitter.
22. Zero and calibrate the DUT sensor to the N1914A power meter (Chan A).
23. Connect the DUT power sensor to the N1914A power meter (Chan A).
24. Connect the DUT sensor to the TEST arm of the power splitter.
25. Set the source frequency to the first (next) test frequency in Table 2.
26. Set the cal factor of DUT sensor (Chan A) to 100% and leave it set to 100%
27. Adjust the source output power so that the REFERENCE sensor reads +/- 0.02 mW of its measured value in Table 1.
28. Copy from Table 1 all of the STANDARD run measurement to Table 2.
29. Locate the full calibration data for STANDARD power sensor and enter the rho/reflection data in the Magnitude and Phase columns of Table 2.
30. Locate the full calibration data for power splitter and enter its equivalent port patch data in the Magnitude and Phase columns of Table 2.

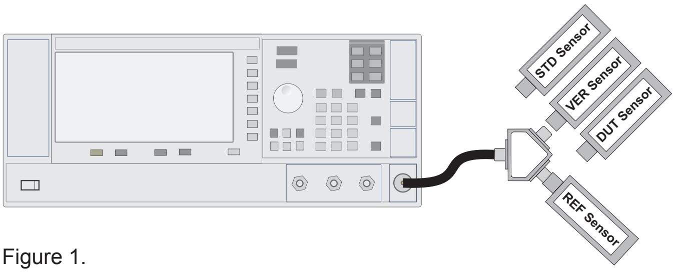


Figure 1.

DUT Cal Factor Calculations

31. Now to calculate the k, or the cal factor of the DUT, using the following formula:

$$K_{DUT} = 100 \cdot \frac{M_{DUT}}{M_{STD}} \cdot \frac{P_{DUT}}{P_{STD}} \cdot \frac{P_{REF-STD}}{P_{REF-DUT}}$$

where

K_{DUT} = calibration factor of DUT sensor,
M_{DUT} = mismatch factor between DUT sensor and splitter,
M_{STD} = mismatch factor between STD sensor and splitter,
P_{DUT} = power indicated with DUT sensor attached,
P_{STD} = power indicated with STD sensor attached,
$P_{REF-DUT}$ = power indicated by REF sensor with DUT sensor attached, and
$P_{REF-STD}$ = power indicated by REF sensor with STD sensor attached.

32. The most complex part of this equation is the mismatch corrections for each data point. Using the following formula and mag and phase data found in Table 2, calculate the mismatch of both the STANDARD SENSOR and DUT.

$$M = \left|1 - \Gamma_A \Gamma_B\right|^2$$

where

Γ_A = the complex reflection coefficient of the sensor port,
Γ_B = the complex reflection coefficient of the splitter port,
$\Gamma = \rho \cdot e^{j\theta}$ (the complex reflection coefficient),
$\rho = |\Gamma| = \frac{VSWR-1}{VSWR+1}$ = magnitude of the reflection coefficient,
θ = phase angle of the reflection coefficient (in radians or degrees), and
$e^{j\theta} = \cos\theta + j\sin\theta$ (Euler's Identity).

EXAMPLE

Suppose
$\Gamma_A = 0.13$ @ 37°
$\Gamma_B = 0.15$ @ 71°

$$M = |1 - [0.13 \cdot (\cos(37°) + j\sin(37°))] \cdot [0.15 \cdot (\cos(71°) + j\sin(71°))]|^2$$
$$M = |1 - [0.0995 - j0.0837] \cdot [-0.0464 + j0.1427]|^2$$
$$= |1 - [(0.0995)(-0.0464) + (0.0837)(0.1427) + j(0.0995)(0.1427) + j(0.08371)(0.0464)]|^2$$
$$= |1 - (0.0073 + j0.0181)|^2$$
$$= |1 - 0.9927 - j0.0181|^2$$
$$= |0.9928|^2$$
$$= 0.986$$

33. Then calculate the mismatch ratio $\frac{M_{DUT}}{M_{STD}}$ by dividing the M_{DUT} value by the M_{STD} value. The resulting values should be close to 1.

34. Copy the P_{STD} **Chan A** P_{DUT} **Chan A** Values from Table 2 into Table 3.

35. The $\frac{P_{DUT}}{P_{STD}}$ ratio is calculated by dividing the P_{DUT} power measurements by the P_{STD} power measurement.

36. Copy the $P_{REF-STD}$ **Chan B** $P_{REF-DUT}$ **Chan B** Values from Table 2 into Table 3.

37. The $\frac{P_{REF-STD}}{P_{REF-DUT}}$ ratio is calculated by dividing the $P_{REF-STD}$ power measurements by the $P_{REF-DUT}$ power measurement. Note: Ideally, $P_{REF-STD} = P_{REF-DUT}$. However, if the signal source is not perfectly repeatable in its power delivery at a set frequency, then $P_{REF-STD} \neq P_{REF-DUT}$ will be true. The $\frac{P_{REF-STD}}{P_{REF-DUT}}$ ratio removes any leveling errors and provides more accurate calibration factors.

38. Now to calculate the k, or the cal factor of the DUT, we will use the following formula:

$$K_{DUT} = 100 \cdot \frac{M_{DUT}}{M_{STD}} \cdot \frac{P_{DUT}}{P_{STD}} \cdot \frac{P_{REF-STD}}{P_{REF-DUT}}$$

Freq (GHz)	M_{DUT}	M_{STD}	$\frac{M_{DUT}}{M_{STD}}$	P_{DUT}	P_{STD}	$\frac{P_{DUT}}{P_{STD}}$	$P_{REF-STD}$	$P_{REF-DUT}$	$\frac{P_{REF-STD}}{P_{REF-DUT}}$
0.050	0.986	0.976	1.010	0.995	1.010	0.985	0.939	0.939	1.000
1.0									
1 GHz Steps									
50									

Table 3.

39. Copy the ratios $\left(\frac{M_{DUT}}{M_{STD}}\frac{P_{DUT}}{P_{STD}}\frac{P_{REF-STD}}{P_{REF-DUT}}\right)$ from Table 3 into Table 4 for simplification.
40. Multiply 100 by the ratio values in each column. The resulting value is the absolute calibration factor of the DUT power sensor.
41. (Optional) If the power sensor is a diode based power sensor like the Agilent N848x or HP 848x power sensor, then its calibration factors can be scaled. For many older power meters like the HP 436A, the cal factors have to be scaled so no value is above 100% because that is the max value for the calibration settings knob.
42. (Optional) Calculate the scaling factor by finding the highest calibration factor in the K_{DUT} Absolute column. Subtract 100 from that number. For example, a calibration factor of 103.6 would be (103.6 – 100 = 3.6). Then subtract that number (3.6) from the 50 MHz reference calibration factor (99.5 – 3.6 = 95.9). The resulting number (95.9) is rounded down to make the reference calibration factor a whole number, so 95.9 becomes 95.0. Subtract that number (95.0) from the 50 MHz reference cal factor in the K_{DUT} Absolute column (99.5 – 95.0 = 4.5). The new scaling factory (4.5) is then copied to every row in the Scaling Factor Column.
43. (Optional) For each row in the table, subtract the scaling factor from the K_{DUT} Absolute column and store that value in the K_{DUT} Scaled column Note: Diode base power sensors, unlike thermistor mounts, are relative measurement devices. They are zeroed then calibrated using the 50 MHz cal port on the power meter. As long as the reference calibration factor and all the other cal factors are scaled equally, the power sensor will make accurate measurements.
44. The uncertainty equation for this process is as follows:

$$\frac{u^2(K_{DUT})}{(K_{DUT})^2}=\frac{u^2(K_{STD})}{(K_{STD})^2}+\frac{u^2(M_{DUT})}{(M_{DUT})^2}+\frac{u^2(M_{STD})}{(M_{STD})^2}+\frac{u^2(P_{DUT})}{(P_{DUT})^2}+\frac{u^2(P_{STD})}{(P_{STD})^2}$$
$$+\frac{u^2(m_{STD})}{(m_{STD})^2}+\frac{u^2(m_{DUT})}{(m_{DUT})^2}+\frac{u^2(P_{REF-DUT})}{(P_{REF-DUT})^2}+\frac{u^2(P_{REF-STD})}{(P_{REF-STD})^2}$$

where

K_{DUT} = calibration factor of DUT sensor,

M_{DUT} = mismatch factor between DUT sensor and splitter,

M_{STD} = mismatch factor between STD sensor and splitter,

P_{DUT} = power indicated with DUT sensor attached,

P_{STD} = power indicated with STD sensor attached,

$P_{REF-DUT}$ = power indicated by REF sensor with DUT sensor attached,

$P_{REF-STD}$ = power indicated by REF sensor with STD sensor attached,

m_{STD} = zero & cal adjustment with STANDARD sensor, and

m_{DUT} = zero & cal adjustment with DUT sensor.

Freq (GHz)		$\frac{M_{DUT}}{M_{STD}}$	$\frac{P_{DUT}}{P_{STD}}$	$\frac{P_{REF-STD}}{P_{REF-DUT}}$	K_{DUT} Absolute	Scaling Factor	K_{DUT} Scaled
0.050	100	1.010	0.985	1.000	99.5	4.5	95.0
1.0	100				99.2	4.5	94.7
1 GHz Steps	100					4.5	
50	100				103.6	4.5	99.1

Table 4.

Analyzing the Effects of Reducing the Ending Zero Vs. Ignoring the Trailing Zero on Measuring Instruments Used for Force Calibration

Henry Zumbrun
Morehouse Instrument Company

Differing opinions are found within the ASTM E28 sub-committee regarding the proper treatment of the trailing zero following the removal of an applied force. The ASTM E28 committee is responsible for the ASTM E74 standard, which is the generally accepted standard for calibration of force-measuring instrumentation in the United States. Prior to the existence of ASTM E74, there was a split-out sub-set from E4 that hardly resembled what is currently found in ASTM E74. The ASTM E74 standard was published in 1974, and the current revision is ASTM E74-13a.

The current standard allows for two different methods—Method A and Method B—for the treatment of the ending zero. Method A defines the deflection calculation as the difference between the deflection at an applied force and the initial reading at zero force. Method B defines deflection as the difference between the deflection at an applied force and a zero value derived from either an average zero (if the loading sequence is zero, load, zero) or an interpolated zero (if a series of forces are applied before return to zero force). Morehouse Instrument Company conducted an analysis consisting of 46 various measuring instruments and analyzed the effect on the Lower Limit Factor, which is the standard deviation of the differences from the predicted response, multiplied by a coverage factor of 2.4.

1.0 Data Collection

Morehouse Instrument Company used data gathered from previous and current calibrations that were performed in accordance with ASTM E74–06. Several load cells from various manufacturers were selected in a random order for this analysis. The actual number of load cells sampled was 46.

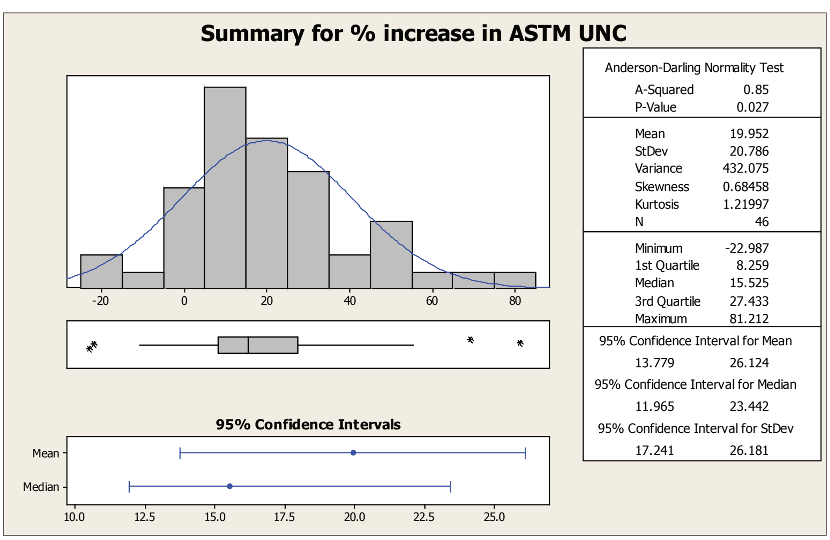


Figure 1. Using 46 ASTM E74 calibrations and not removing the ending zero resulted in an average increase in the ASTM E74 uncertainty of 19.952%.

2.0 Data Analysis

The calibration data gathered from 46 different calibrations was curve fit in accordance with ASTM E74-06 which requires that the trailing or ending zero be considered as part of the calibration per section 8.1 of ASTM E74-06:

> **8. Calculation and Analysis of Data**
>
> 8.1 *Deflection*—Calculate the deflection values for the force-measuring instrument as the differences between the readings of the instrument under applied force and the averages of the zero-force readings taken before and after each application of force. If a series of incremental force readings has been taken without return to zero, a series of interpolated zero-force readings may be used for the calculations. In calculating the average zero-force readings and deflections, express the values to the nearest unit in the same number of places as estimated in reading the instrument scale. Follow the instructions for the rounding method given in Practice E 29.

This data was referred to as ASTM E74 Unc with Trailing Zero or this data was calculated in accordance with ASTM E74-06, which is referred to as Method B in ASTM E74-13a.

The raw data was curve fit a second time ignoring any change in 0 during calibration. For the purpose of this test the beginning zero was used as the ending zero. If an instrument had a beginning zero of 0.00040 then an ending zero of 0.00040 was used. If the Instrument had a beginning zero of 0.00040 and an ending zero of 0.00075 then 0.00040 was used.

This data was referred to as ASTM E74 Unc Ignoring Trailing Zero.

The following equation (ASTM E74 Unc Ignoring Trailing Zero - ASTM E74 Unc with Trailing Zero)/ ASTM E74 Unc Ignoring Trailing Zero))*100 was used to determine the percentage change in ASTM Uncertainty or ASTM Lower Limit Factor (LLF).

Figure 1 shows that use of method (A) ignoring the trailing or ending zero results in an increase of the ASTM E74 Lower Limit Factor (LLF) for the majority of instruments calibrated.

The P-Value of 0.027 for the Anderson-Darling Normality Test indicates this data sample does not follow the normal distribution. Therefore the following discussion will focus on the median and IQR (Interquartile Range).

The sample median (15.525), range (-22.987 – 81.212), 1st Quartile (which represents 25% of the sample population = 8.259) and 3rd Quartile (which represents 75% of the sample population = 27.433) indicates the middle 50% of the data (data between the 1st and 3rd Quartiles ranges from 8.259 to 27.433). The population median can be expected to vary between 11.965 to 23.442 at the 95% confidence level. This 95% confidence interval roughly predicts that in 95 out of 100 future samples, the median can be expected to fall between 11.965 to 23.442. (Note: The majority of the instruments calibrated will fall in this range, which will result in an increase in ASTM Lower Limit Factor.)

The graph below (Figure 2) shows the individual value for each sample.

This data was also broken down by the manufacturers of these specific load cells (Figure 3). We excluded cells and any force measuring instruments sold or manufactured by Morehouse, since we have several varieties of force measuring instruments that exhibit different characteristics. For example, some multi column load cells should have a better zero return than a single column load cell. We also prefer and recommend Method B for any force-measuring instrumentation manufactured by Morehouse.

In some instances, removing the trailing zero actually improved the Lower Limit Factor; in others, the removal of the trailing zero increased the Lower Limit Factor above 0.025% of full scale. An analysis of the variance, popularly known as ANOVA, was used since there are more than two groups of manufacturers. ANOVA analysis by manufacturer, on the following page (Figure 4), shows that there is no difference in the means of the % increase in ASTM LLF. The standard deviations were also found to be statistically equal. The dataset was slightly reduced for this analysis by removing manufacturers with only one instrument in the sample. Ideally, more samples per manufacturer would have been preferred, but the sample size was sufficient for the ANOVA and tests for equal standard deviations.

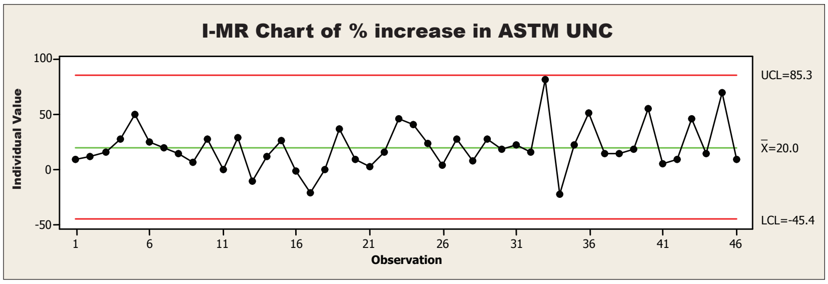
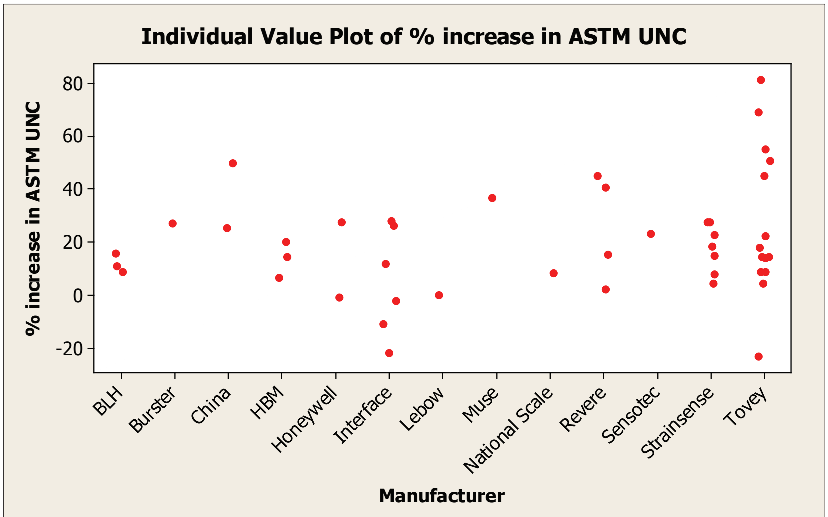


Figure 2.



Variation in % increase in ASTM uncertainty by removing the trailing zero

Figure 3.

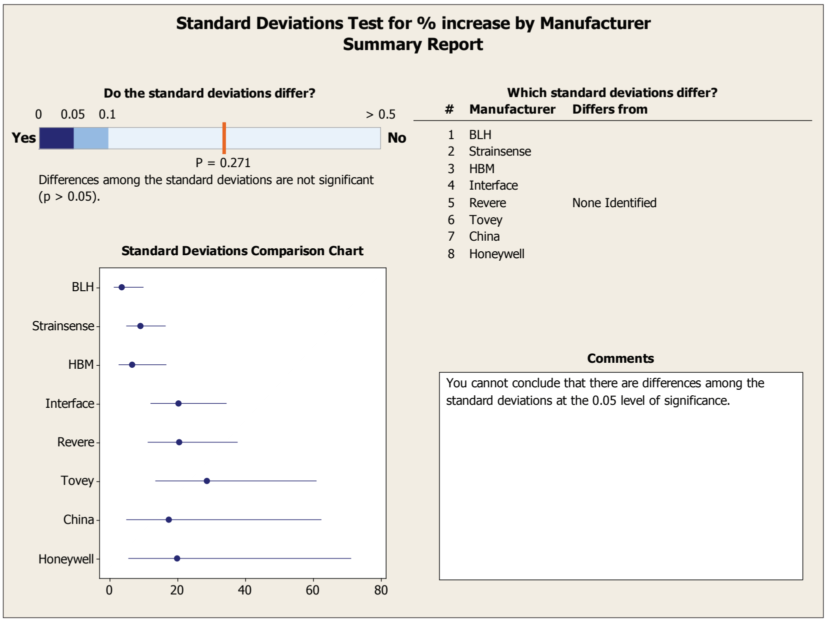


Figure 4.

3.0 Data Analysis – Change in Full Scale Output

The raw data gathered from 46 different calibrations was curve fit in accordance with ASTM E74-06. The full scale output was recorded with and without the ending zero being removed from the full scale output.

The raw data was curve fit a second time, ignoring any change in 0 during calibration. For the purpose of this test, the beginning zero was used as the ending zero. If an instrument had a beginning zero of 0.00040 then an ending zero of 0.00040 was used. If the instrument had a beginning zero of 0.00040 and an ending zero of 0.00075 then 0.00040 was used.

The data with the trailing zero reduced from the full scale output is referred to as Net Output @ Capacity with 0. The data without the trailing zero reduced is referred to as Output @ Capacity no Trailing 0.

To calculate the percentage change the following formula was used ABS((‘Net Output @ Capacity with 0’-’Output @ Capacity no Trailing 0’)/’Net Output @ Capacity with 0’*100) to determine the % change in capacity between the current treatment of zero versus the proposed.

The graph below (Figure 5) shows method (A) ignoring the trailing or ending zero results in a difference of full scale output for the majority of instruments calibrated.

This increase can be summarized by analyzing the median (0.002479), which shows that in 95 out of every 100 calibrations in future samples, the full scale output difference between method B and method A (Ignoring the trailing zero) would be expected to vary between 0.0014% to 0.0034% by not removing the trailing or ending zero. The median is used for this sample given the sample does not follow the normal distribution.

This data was also broken down by the manufacturers of these specific load cells (Figure 6 on the following page).

Out of 46 samples, 1 load cell exhibited a very significant change in full scale output. We would consider this load cell an outlier. Further evidence would suggest that this load cell was not fit for calibration as the zero balance was quite high, indicating a possibility of mechanical damage. This is typically the result of a load cell being overloaded. When a load cell is overloaded, residual stresses and strains are introduced into the structure. The past mechanical history of the flexure, gauge alloy, backing and adhesive is altered. As a result, the load cell symmetry is modified, and the compression and/or tension output deviates from what it was prior to overload. Strain Gauge characteristics are modified,

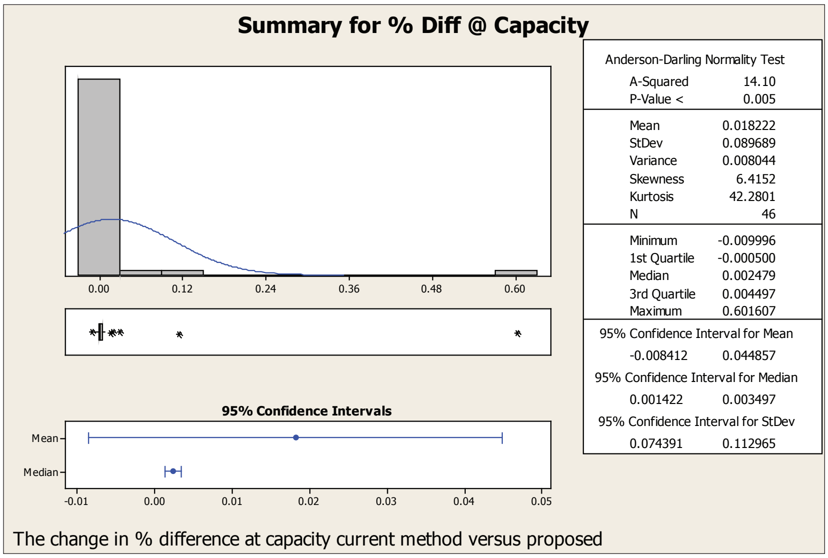


Figure 5. Shows method (A) ignoring the trailing or ending zero results in a difference of full scale output for the majority of instruments calibrated.

such as Resistance and Gauge factor, which will modify the temperature coefficients. This is important to note, since anyone using a load cell that has been overloaded may have very large unaccounted error sources, and all force measurements made with this device are suspect. Several methods and devices can be used to test a load cell to determine if it has been overloaded. These devices range from handheld meters, load cell testers which are made specifically for this purpose, to high end meters.

4.0 Closing Comments

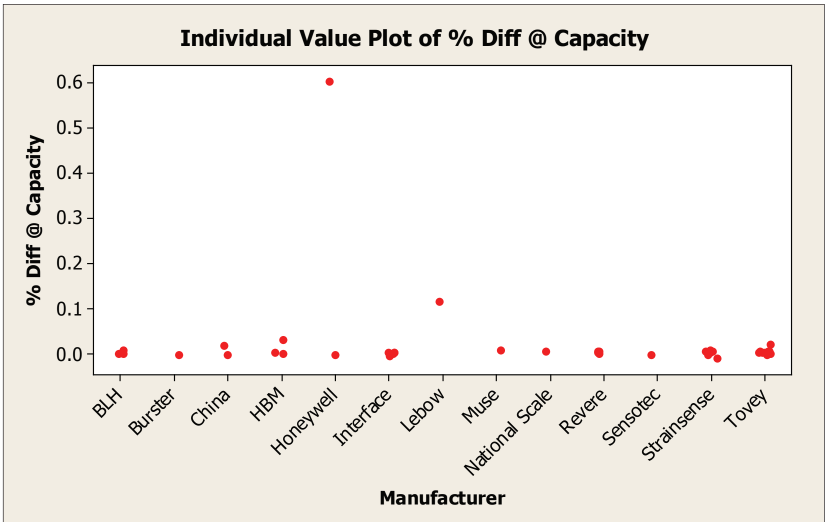
This analysis shows that following ASTM E74-13a Method (A), which ignores changes in zero during calibration, will increase the LLF (Lower Limit Factor) median value between 11.9% to 23.4% assuming 95% confidence interval.

The end user of any measuring system should evaluate how the instrument is being used and notify the laboratory performing the calibration of the appropriate method for the normalization of data. These tests can be applied to almost any non-mechanical force measuring instrumentation, and any laboratory performing calibrations on force measuring instruments should report to the end user the zero reduction method used, along with the values of the trailing zero recorded during calibration.

Timing between recording force values and trailing zeroes was between 25 and 30 seconds after the application or removal of force. Differences in timing may also contribute to an additional uncertainty component that should be considered.

Mechanical Instruments were not considered for this test as it has been widely accepted that a change in zero must be accounted for.

Henry Zumbrun, Morehouse Instrument Company, 1742 Sixth Avenue, York, Pennsylvania, US, hzumbrun@mhforce.com.



Variation in the % of full scale output by removing the trailing 0

Figure 6.

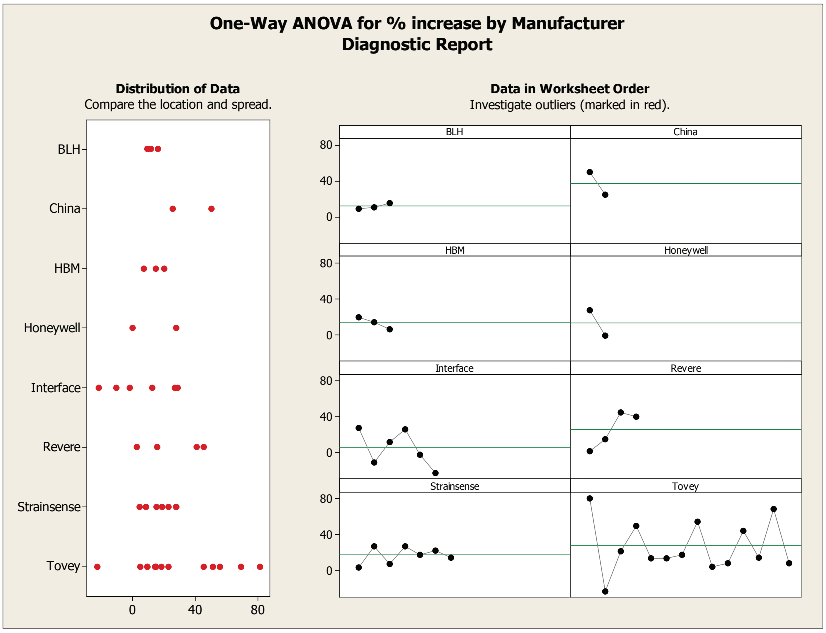


Figure 7. Percentage increase in ASTM LLF (Lower Limit Factor) by manufacturer.

Documentation & Document Control

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There is an old saying, "Say what you do" and "Do what you say." This saying is the essence of the whole matter of laboratory management, operation and accreditation. I always like to emphasize this statement because it really sums up what needs to be done to operate a laboratory in a most consistent and efficient way. This article addresses Documentation and Document Control. It covers the work that must be done to organize, prepare and implement an effective documentation system that addresses the "says what you do" part of the saying. I hope you will find the following information to be helpful as you look over your document system and consider what might be done to make improvements.

Introduction

All documents used within a laboratory need to be identified and controlled. Management needs to be sure all documents have been identified and actions taken to ensure all requirements for control are covered. I often use a diagram (shown on the next page) to graphically show the magnitude and complexity of documentation and the documentation hierarchy that exists within a typical laboratory or most any other organization.

Documentation

Level 1 at the top of the pyramid (Figure 1) identifies and references all National and International Standards and Regulatory requirements that have an effect on laboratory operations. In addition, the top level should include any documents that, by Contract impose requirements on the laboratory in support of laboratory customers. These documents must be identified and their requirements analyzed and met. There are many such documents and they dictate what must be done by the laboratory. This is one of the most basic elements of the Laboratory Management System. Requirements in these documents must be identified, cataloged, analyzed and implemented in the documented operational procedures as listed in level 1 through 4 in the pyramid. This is a very important, basic first step in establishing a well organized and managed document control system.

Level 2 includes documents such as the Quality Manual and any other documents promulgated by the executive. The Quality Manual is really a marketing tool. It introduces customers, prospective customers and employees to the laboratory organization. It identifies where the laboratory is located, what type of services the laboratory is qualified to provide and how to make contact. It also provides the Policy, Vision and Commitment as promulgated by the top executive. Because the Quality Manual can be made available to the public as a marketing tool it should not contain any proprietary information such that contained in any lower level documents. The Quality Manual should also include or reference the laboratory's Master or Composite list that identifies all SAPs, SOPs and WIs.

Level 3 identifies all procedures used by the laboratory to document what has to be done and how it is to be done. These documents are normally considered as proprietary in nature and should only be released under the authority of the top executive. They should be identified and segregated as Standard Administrative Procedures (SAP), Standard Operating Procedures (SOP) and Work Instructions (WI). The third level is composed of a very large number of documents. The laboratory will need to document all activities accomplished by the laboratory. This includes SAPs that cover such items as, but not limited to: identifying the laboratory's organizational structure, along with defining the functions and responsibilities within the organization and a list of job descriptions; a Training Program, Documents and document control; and, how to conduct Management Reviews. SOPs are used to describe how technical processes are to be accomplished. This would include, but not be limited to: management and control of laboratory facilities, laboratory equipment and a repair program. This is just a few examples of procedures that will need to be developed, documented and implemented to ensure effective, efficient operation and control of all laboratory processes.

Level 4 identifies all forms, records, checklists and other such items used to process and record events. All of these items need to be identified along with detailed instruction that tell the user how to use the form and what needs to be done to process the results and where these forms are to be stored when completed. These forms become the records that document proof of accomplishment and compliance to requirements, a very important element of document control.

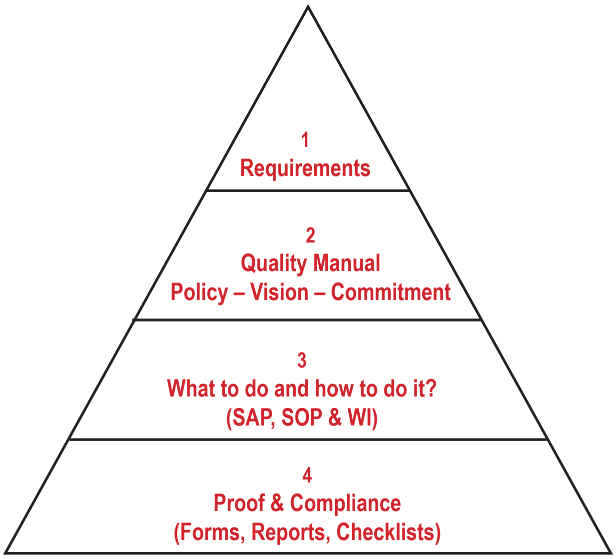

Figure 1. Document Pyramid

Document Control

A Standard Administrative Procedure (SAP) should be developed that will document "how" Document and Document Control requirements and operations are to be accomplished. The administrative activity involving Documentation should be a key element of a laboratory's designated library operations. The control and management of all information contained in the database should be reviewed, monitored, revised and controlled by a Document Control Board (DCB). Up-dates and changes to the composite list might best be accomplished as part of library operations. The official database information should be available to all members of the laboratory in an electronic, computerized format. The library group should be responsible for assuring operation of the automated database. The library group should also be responsible for in-putting all revisions and up-dates to operational documentation. The library should work with the DCB and assigned authors to assure that document control is maintained. The library, in coordination with the DCB, should also be responsible for coordinating, developing, documenting and implementing the SAP that covers documentation.

Document Format

There should be a standardized format used for the layout of Administrative and Operational Procedures.

Note: *Document approval, issue and control responsibilities should be defined and included in the Organization and Functions & Responsibilities charts as identified in the SAP covering Laboratory management and organization.*

Cover – A standardized format, including: a unique document number, title, issue and revision dates and name of the group or individual that prepared the document and the signature and date of the approving authority. This should be followed by:

Section 1 – Table of Content
Section 2 – Introduction
Section 3 – Reference Documents that apply to the subject matter
Section 4 – Procedure (What to do and how to do it.)
Section 5 – Sample of checklists, reports and labeling along with instructions
Section 6 – Subject matter index

The SAP covering Documentation should also provide detailed information as to how all types of documentation are made available within the system. In addition to these activities, there should be follow-up activity that confirms implementation of all elements of the process. This should be included in the SOP covering Internal Audit.

Note: *There are four basic actions regarding documentation that should be included in the SAP. Each of these activities should be headlined followed by a narrative that describes how these processes are to be accomplished. The reason this is so important is that it requires management to think about, determine and document the most efficient way to accomplish these activities. How these activities are accomplished should also be included as part of the training program and included in the Document Control SAP. The actions are:*

1. **Communication** State how information is communicated within your laboratory. The communication process is normally accomplished through the indoctrination process, as part of the formal training program, on-the-job training, weekly meetings, and required readings. Describe in the SAP "how" this is to be accomplished within your laboratory. Be sure there are records (forms) designed to document when and how individuals receive this information.

2. **Comprehension** How do you know the documentation is understood by an individual? Do not simply require that individuals read a document and sign that they have read and understand the material. That approach is unacceptable. It does not provide management with any knowledge of how well an individual has absorbed and understands the material. There needs to be documented evidence that the degree of understanding is measured through some form of testing. Verification can range from a written examination and demonstration for relatively complex processes to a simple question and answer session documented with a knowledgeable examiner. This activity needs to be

included in the individuals training file, a form used to document that management has verified that an individual understand appropriate processes. This type of activity is also used as a basis by management to qualify and authorize personnel to accomplish certain types of work. It can also be used as a basis for promotional opportunities.

3. **Availability** Management needs to describe how documentation is made available to personnel. At some laboratories, traditional hard copy documents are still used. If that is the case with your laboratory, you will need to describe how these documents are made available to personnel. For the "hard copy" approach, it can be a rather involved process for making distribution and describe how information is updated over time to ensure personnel are working with the latest criteria. When management implements an automated process for distribution and update of documents, the entire process is far more efficient and much easier to use, maintain and control. In any event, you need to describe in detail how this is accomplished in your laboratory. If the laboratory is still in a hard copy mode, management might consider this as an objective, (opportune time) to transition to an automated system over a set time period. This is the type of activity that contributes to improving the effectiveness of the management system and is consistent with the objective for improvement over time.

4. **Implementation** How does management determine if system documentation is being implemented within the laboratory? Implementation needs to be measured. This should be accomplished through proficiency testing, inter-laboratory comparisons and independent regulatory or third-party assessment. Feedback from customers can also help to identify how well the overall system is being implemented. All these events should be documented and recorded as part of each individual's training record. This activity should be monitored and reported on as an integral part of the Internal Audit Program. The degree of implementation should be addressed and progressed as part of the annual Management Review.

The following are some additional comments about the documentation process:

Document Review – Regarding the List of Documents in Column 8 (see Table 1). The Quality Manual should require that the laboratory establish a review period for each document and ensure that all reviews are accomplished on schedule.

Changes – Responsibility for changes to documents can be identified in Column 3 of the List of Documents. Management will need to include detailed procedures in the SAP that describe how the change process works and identify those responsible and authorized to cause the changes to be made and how the changes are to be implemented. However, there needs to be a "how to" procedure in the appropriate SAP that describes how the review and change process is to be accomplished and by whom.

Altered Text – Methods for identifying new or altered text should be included in the SAP for documentation. It helps to ensure that the most current and up-to-date information is highlighted and brought to the attention of the reader.

Amendments – Management's position regarding amendment of documents needs to be stated in the Quality Manual. If amendments are to be allowed then detailed procedures will need to be included in the SAP that describes how this process is to work. As a minimum, it will define authorities for making such amendments, how amendments shall be clearly marked, initialed, and dated and that the revised document be re-issued as soon as practicable. In some cases, laboratory management may simply state that amendments are not allowed.

Numbering Convention – Including a numbering convention is away to quickly identify where a topic of discussion is located in the procedure. It is an efficient communication process. It is also helpful as a part of the change control process.

Composite List of Documents

This is one of the primary tools that can be designed to help management control documentation. The following table (see Table 1) is a sample of a Composite/Master list with representative arrangement and numbering of individual documents along with columns that are responsive to many traditional requirements for document control. It enables management to inventory and identify all the documents within the laboratory's management system.

Automated Database – Although shown in a paper format, the matrix should be set-up in a database so it is easy to keep up to date and enable the data to be sorted, manipulated and utilized in support of other programs as well as for Document Control.

Note: *The following matrix is only presented to show how the list of documentation might be organized in a computerized, automated database and what information, as a minimum, should be included in the database. If organizations elect to organize their documentation in this way, they will need to design and develop a Master or Composite List that is appropriate to their method of operation.*

The following information is provided as it relates to the columns shown below in Table 1:

Column 1 – Document Number – Identifies the Document number. Management needs to decide how to arrange documents and how to divide them up into functional categories. In this case, the traditional terms of Requirements, Policy, Standard Administrative Procedure (SAP), Standard Operating Procedure (SOP) and Work Instruction (WI) are used. It is not necessary to use these terms, but whatever terms are used should have some form of logic to their arrangement.

Column 2 – Title – Identifies the name of the document. Important because it helps to identify the subject matter contained in the document.

Column 3 – Issuing authority – This column identifies the functional position that has responsibility to see that the document is prepared, proofed, published, disseminated, reviewed and maintained. For in-house personnel, the individuals should be assigned by the issuing authority and be responsible for maintaining the content of the assigned document.

1	2	3	4	5	6	7	8	9	10
Doc No.	**Title**	**Auth.**	**Issue Date**	**Rev. No.**	**Rev. Date**	**Dist. List**	**Review Period**	**Obsolete Date**	**Page Count**
	REQUIREMENTS								
ISO/IEC 17025	Gen. req. for competence of Testing & Calibration Laboratories	ISO/IEC							
ISO 9002	Quality system – Model for quality assurance and servicing	ISO							
Contract 1	Contract # & Title								
	Etc.Etc. -								
	POLICY								
QM-01	Lab. Quality Manual								
QM-02	Other Exec. Documents								
	SAP (Std. Administrative Procedures)								
SAP-001	Organization								
SAP-002	Management System								
SAP-003	Contracts								
SAP-004	Subcontracting								
SAP-005	Purchasing								
	SOP (Std. Operating Procedures)								
SOP-001	Documentation								
SOP-002	Service to customers								
SOP-003	Complaints								
SOP-004	Nonconforming Work								
	WI (Work Instructions)								
WI-0001	Calibration of --------								
WI-0500	Test of --------								

Table 1. A sample of a Composite or Master List of documents.

Column 4 – Identifies the original issue date when the document was first published needed to document the chronological progress from cradle to grave.

Column 5 – Identifies the current revision number for the document that is in effect and authorized for use.

Column 6 – Identifies the date of revision.

Column 7 – Identifies the distribution for the document. Included in the SOP for Document Control should contain established distribution lists. Normally these levels of distribution are identified by a Distribution List that identifies where specific documents are to be distributed. The appropriate distribution is then identified in column 7.

Column 8 – Identifies how often documents need to be formally reviewed to ensure the document is still current and up-to-date. Sometimes the term "periodically reviewed" is used. Management should not use the term 'periodic' but rather identify a specific time when the review must be done. This is basically a maintenance program and needs to be accomplished on schedule. Column 8 allows the issuing authority to consider how often a review is needed depending on significance of the document. Not all documents need to be done to the same periodicity. Typically, reviews are done anywhere from less than a year to as much as 3 to 5 years depending on the nature and stability of the documented process.

Column 9 – Identifies those documents management has classified as obsolete and documents the date these documents were placed in this classification. There also needs to be a "how to" procedure in the appropriate SAP that describes how documents are to be removed, how they are to be marked, by whom, and where they are to be controlled, stored and disposed of when appropriate.

Column 10 – Page count – How big is that elephant? Page count is not a requirement imposed by any Standard. However, I suggest it be included so management can measure the size of the documented management system. Documentation is costly in terms of the effort is takes to develop and maintain the entire inventory of documentation. One way to improve and make the system more efficient is to know the size of each document and then set an objective or goal. During periodic reviews, the reviewing official should make recommendations where appropriate review that would help to reduce the number of pages required for operating the system in the most efficient, effective way. This activity can be accomplished and reported as part of the periodic review process and is in support of the requirements for continual improvement. What is the word count for your laboratory?

Conclusion

This article has covered the matter of documentation and document control. It covers the process of documenting the "say what you do" part of the overall laboratory management program. The recommendations provided in this article should help to ensure all activities in the laboratory are always conducted in a consistent, standardized manor. Considerable attention should be given to ensuring that all laboratory documents are identified, documented, proofed and are always being used to consistently conduct laboratory operations in accordance with established procedures.

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Report of an Interlaboratory Comparison of Phase Noise on a Fluke 9640A-LPN Signal Generator

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In 2013 and 2014, the U.S. Army Primary Standards Laboratory piloted a six-laboratory intercomparison (ILC) of phase noise measurements using a Fluke 9640A-LPN signal generator as the test article. The article was tested at 0.5 GHz, 1 GHz, and 4 GHz at offset frequencies of 10 Hz, 100 Hz, 1 kHz, 10 kHz, 100 kHz, 1 MHz, and 10 MHz. The National Institute of Standards and Technology (NIST) provided the phase noise measurements to which the measurements of the other participating laboratories were compared. The only issue encountered during the ILC was a small spur at 1 GHz and 10 MHz offset. Since it only affected one lab and the spur's effect was known, it was still included in the results. Only one laboratory had one averaged reading with a normalized error greater than one.

Phase Noise Basics

Phase noise, which is also referred to as phase modulation noise (PM noise), is caused by small random fluctuations in the phase of a signal. We specify and measure phase noise because it is a fundamental limitation in the performance of systems and limits the dynamic range. An ideal signal can be defined as $V(t) = A \sin 2\pi f$, where A is the peak amplitude and f is the frequency. In reality, the signal is $V(t) = [A + B(t)] \sin [2\pi f + \Phi(t)]$, where B(t) is the random amplitude fluctuations (AM noise) and $\Phi(t)$ is the random phase fluctuations (phase noise). Phase noise is the ratio of the noise power in a 1 Hz bandwidth, at a specified offset from the carrier, to the carrier signal power [1]. Phase noise may be expressed in the units dBc/Hz, and it tends to decrease as the offset frequency increases. Double-sideband phase noise is the upper plus the lower sideband phase noise while single-sideband (SSB) phase noise refers to the amount of noise on only one side of the carrier signal. Single-sideband phase noise is one-half (3 dB lower than) the double-sideband phase noise since the upper and lower sidebands of the signal are generally assumed to be the same, and phase noise is usually reported as SSB phase noise. All phase noise measurements in this paper are given as SSB phase noise.

Thermal noise is noise caused by the agitation of electrons in a conducting medium. It is considered a limiting factor because it is always there. It varies with temperature, but a decrease of 1 dB requires a decrease in temperature of about 60 degrees Celsius. The lower limit of thermal noise at room temperature is -174 dBm/Hz. Half of this is considered AM noise and the other half phase noise, so the thermal noise lower limit for phase noise is -177 dBm/Hz. When we measure phase noise near this value, the thermal noise starts interfering with measurements. All measurements in this ILC were taken at a signal generator power level of +13 dBm, so the thermal noise lower limit is -190 dBc/Hz. Phase noise readings of -160 dBc/Hz or higher (30 dB above the lower limit) would be 0.00 dB higher due to thermal noise. When the generator's phase noise is 20 dB higher than the thermal noise, the generator's phase noise measures 0.04 dB higher; when it is 10 dB higher, its phase noise is 0.41 dB higher. This illustrates that when the generator's phase noise approaches the thermal noise, the phase noise measurements will be higher if thermal noise is not accounted for. The effect this would have on phase noise measurement systems that use two or more generators and do not null out the thermal noise is beyond the scope of this paper. All of the measurement results for this ILC were higher than -157 dBc/Hz. If the participating labs used 3 dB input attenuation on their phase noise systems there would still be 30 dB minimum difference between the signal generator noise and thermal noise. If they used 10 dB input attenuation there would be 23 dB minimum difference, resulting in a 0.02 dB increase. Since this is very small, thermal noise would still not significantly affect the measurements.

Disclaimer: References to commercial equipment in this article do not imply endorsement by the author or the U.S. Government, nor do they imply that the equipment is necessarily the best available for the purpose.

Introduction

In 2013 and 2014 the U.S. Army Primary Standards Laboratory (APSL) piloted a six-laboratory intercomparison in phase noise using a Fluke 9640A-LPN as the test article. NCSLI Recommended Practice 15 [2] was used as the reference for establishing the protocol for this ILC. The APSL also served as the pivot laboratory, and the basic circular pattern for scheduling was used. The test article was measured at the pivot lab, sent to each of the other labs for measurement, and ended back at the pivot lab, where it was measured again to check for drift. The ILC was coordinated by the APSL and included the following participants: U.S. Air Force Primary Standards Laboratory, the National Institute of Standards and Technology (NIST), Agilent Technologies Santa Rosa Metrology Services, the Anritsu Company Standards Laboratory, Fluke Electronics Everett Service Center, and National Instruments. For confidentiality, the participating labs are represented by the letters A through F. The purpose of this ILC is to provide an appraisal of the capabilities of the participant laboratories by measuring a low phase noise signal generator at three frequencies: 0.5, 1, and 4 GHz. The phase noise was reported at offset frequencies of 10 Hz, 100 Hz, 1 kHz, 10 kHz, 100 kHz, 1 MHz, and 10 MHz. The power level of the signal generator was 13 dBm for all frequencies. The NIST cross-spectrum phase noise measurement system was used as the standard for this ILC. It is pictured schematically below and described by Archita Hati as follows:

Figure 1 shows a two-channel, cross-spectrum phase noise measurement system [3-4] used for inter-laboratory comparison (ILC) of Fluke signal generator (the device under test - DUT). It uses two reference oscillators (Ref #1 and Ref #2) and two phase noise detectors (PDs) operating simultaneously. Each individual channel is a simple heterodyne measurement system. A phase locked loop (PLL) is used in each channel to lock the reference oscillator to the DUT; it also maintains phase-quadrature (90°) between two signals at the PD inputs required for phase noise measurement. The output of each PD after amplification is analyzed with a two-channel cross-spectrum fast-Fourier-transform (FFT) analyzer. Each output produces voltage fluctuations that represent a joint contribution of correlated phase fluctuations of the DUT and uncorrelated noise of the reference oscillator, PD, IF amplifier and PLL. Computing the cross-spectral density of voltage fluctuations between two channels improves spectral resolution of noise measurements by eliminating the effect of uncorrelated noise sources in each channel by $\sqrt{N}$, where N is the number of averages of the FFT. The cross-spectrum measurement technique makes it possible to achieve an accurate measurement of the phase noise of

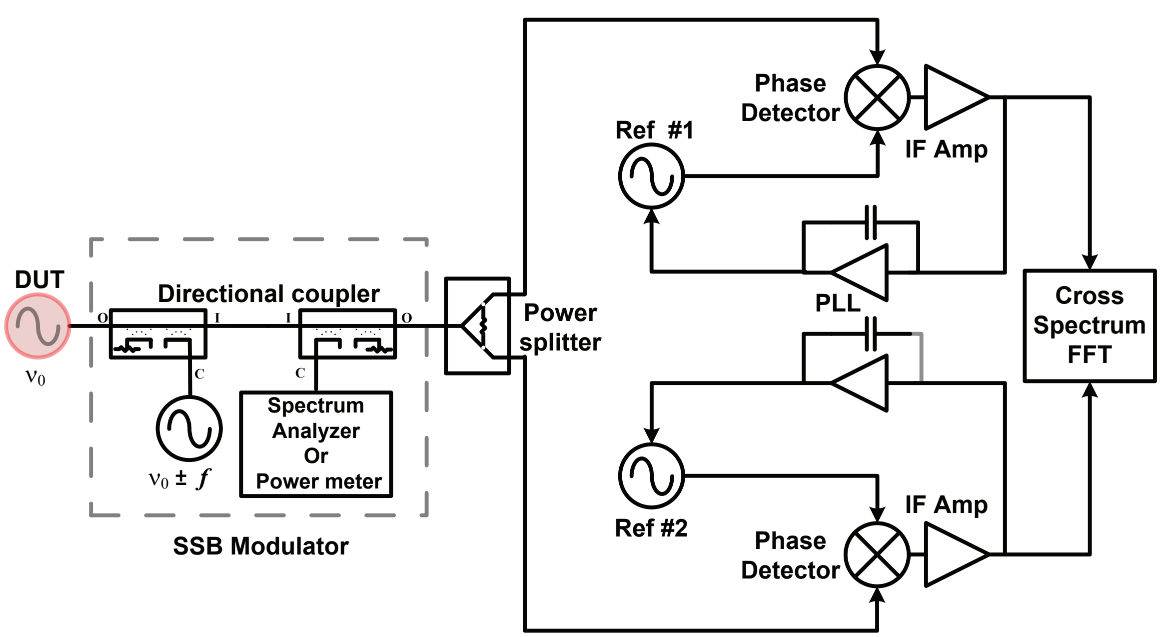

Figure 1. Block diagram of the cross-spectrum phase noise measurement system.

an oscillator that has lower noise than the reference oscillators. For the ILC, the power levels at the LO and RF ports of both PDs were adjusted to obtain the maximum AM rejection of the DUT and the reference oscillators to minimize the bias from AM-to-PM conversion.

A single sideband modulator at the output of the DUT in Figure 1 is used to determine the sensitivity of the measurement system [5] versus offset frequency, both inside and outside of the PLL bandwidth. A sideband of frequency of either '$\nu_0 + f$' or '$\nu_0 - f$' is added to the carrier at ν_0. For a small modulation index, this generates equal amount of phase modulation plus amplitude modulation at f given by

$$S\varphi\,(f) \cong S\alpha\,(f) \cong \frac{P_{\nu_0} + f}{2P_{\nu_0}} \cong \frac{P_{\nu_0} - f}{2P_{\nu_0}} \qquad (1)$$

where, $S\varphi$, $S\alpha$, $P_{\nu_0} \pm f$ and P_{ν_0} are the double sideband (DSB) phase noise, DSB AM noise, sideband power and the carrier power respectively [6].

Measurement Technique

The test article, a 9640A-LPN signal generator with 50 ohm leveling head, was measured by each lab on three separate occasions (days) with three measurements on each occasion. This resulted in a total of nine measurements for each data point and 21 data points (3 frequencies times 7 offset frequencies). All of the measurements listed in this article are the averaged values. Initial measurements were made by the pivot lab before sending the test article to the first participating lab, and final measurements were made after returning to the pivot lab from the last participating lab. The final measurements of the pivot lab and the measurements from the other participating labs are included in this paper. All participants reported their measurements in dBc/Hz, to two decimal places, and provided estimates for their uncertainty.

	0.5 GHz		1 GHz		4 GHz	
Offset	Drift	Std Dev	Drift	Std Dev	Drift	Std Dev
10 Hz	0.01	0.92	0.97	1.41	-0.19	1.26
100 Hz	-0.39	0.94	-0.01	1.42	0.76	1.10
1 kHz	0.59	0.59	0.26	0.35	0.20	0.61
10 kHz	0.16	0.80	-0.77	0.30	0.94	0.31
100 kHz	0.37	0.48	0.10	0.35	0.66	0.45
1 MHz	0.05	0.32	-0.57	0.39	-0.53	0.35
10 MHz	-0.69	0.70	-0.31	1.23	0.26	0.20

Table 1. Drift and Pivot Lab Standard Deviations.

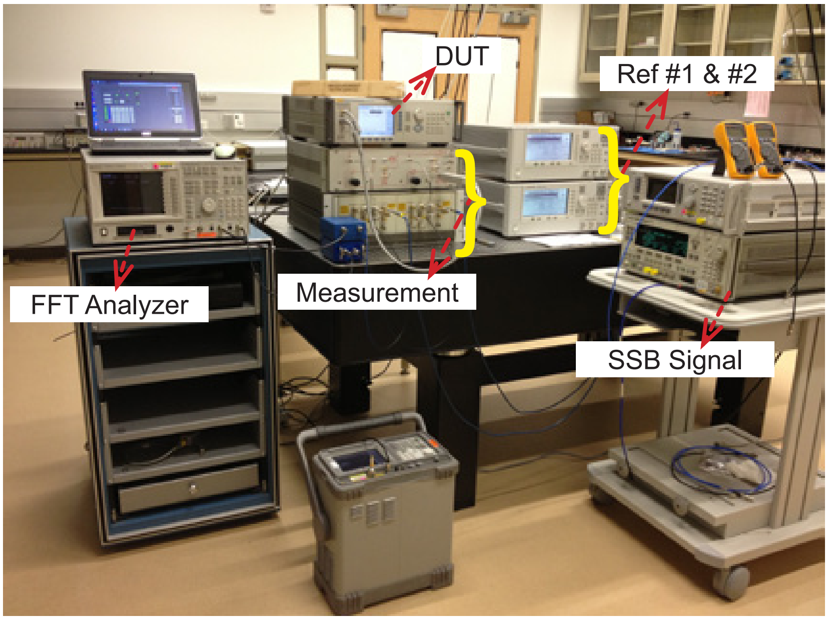

Figure 2. Experimental set-up at NIST.

Results

The test item left the pivot lab on 13 August 2013 and returned on 28 February 2014. The item drift is the average of the readings after the item returned to the pivot lab minus the average of the readings taken before the item left the pivot lab. The drift in dB is listed in Table 1. The drift results are typically about the same as the pivot lab's standard deviation. This indicates that it may not be drift, but just the randomness and uncertainty of the pivot lab's phase noise measurement system.

The NIST readings were used as the standard to which the other labs' readings were compared. The averaged NIST measured values in dBc/Hz along with the uncertainty and standard deviation in dB are listed in Table 2. The participating labs' averaged results minus the NIST averaged measured values are shown in Figure 3.

A spurious signal (spur) is an undesired signal produced by the item being tested. It is stable in frequency and amplitude. NIST found a small spur that was approximately 2 dB higher at a 1 GHz carrier frequency and 10 MHz offset, so they measured the phase noise at 9.995 MHz offset

Frequency	Offset	PM Noise	Std Dev	Unc
500 MHz	10 Hz	-80.36	0.23	0.46
	100 Hz	-112.37	0.21	0.47
	1 kHz	-136.24	0.13	0.52
	10 kHz	-142.66	0.31	0.49
	100 kHz	-142.05	0.18	0.48
	1 MHz	-153.57	0.22	0.58
	10 MHz	-155.44	0.12	0.66
1 GHz	10 Hz	-75.05	0.29	0.47
	100 Hz	-107.34	0.32	0.48
	1 kHz	-131.40	0.17	0.51
	10 kHz	-138.03	0.23	0.48
	100 kHz	-136.91	0.42	0.47
	1 MHz	-151.45	0.38	0.61
	10 MHz	-152.31	0.19	0.60
4 GHz	10 Hz	-62.46	0.33	0.50
	100 Hz	-94.43	0.18	0.48
	1 kHz	-118.59	0.24	0.49
	10 kHz	-125.44	0.18	0.47
	100 kHz	-124.43	0.14	0.48
	1 MHz	-142.36	0.36	0.61
	10 MHz	-148.00	0.29	0.48

Table 2. NIST Results.

instead of 10 MHz there. All of the other labs, except lab A, had readings similar to or lower than NIST at this point, so it did not appear to affect their readings significantly. Lab A noted that the spur was visible in their measurements. They measured 2.15 dB higher at that point. This is still within lab A's measurement uncertainty and if you subtract the 2 dB from it, it decreases to only 0.15 dB higher than NIST measured at 9.995 MHz offset. This point was still included in the data since it only affected one lab and we know its effect on that lab.

The normalized error (E_N) is given by the following equation:

$$E_N = \frac{x - X}{\sqrt{U_{NIST}^2 + U_{lab}^2 + drift^2}} \quad (2)$$

where

x = the lab's measured value;

X = the NIST measured value;

U_{NIST} = NIST's measurement uncertainty;

U_{lab} = the lab's measurement uncertainty; and

drift = the pivot lab's measured value when it returned, minus the measured value before it left.

A normalized error of less than -1 or greater than +1 is considered unsatisfactory [2]. All of the labs except one had all normalized errors between +1 and -1. Lab E had one reading outside that range. At a carrier frequency of 4 GHz and 10 Hz offset lab E's normalized error was -1.16. The normalized errors are displayed in Figure 4.

Conclusions

The phase noise of signal generators is not a precise quantity whose value is stable with time. However, overall, the ILC participants obtained consistent results with low standard deviations. The measured drifts were low, consistently less than one dB. This shows that the artifact is stable and care was taken in the handling and shipping of it. In order to identify issues up-front that most participating labs may not notice, the test article could be sent to the reference lab first in future ILCs. If an issue is found, such as the spur encountered in this ILC, the test article could then be measured at a slightly adjusted point by all participants. It also would be preferable to have a lab with lower uncertainties and standard deviations to measure for drift and measure it at least two extra times in the transportation process to verify that it is actually drifting toward the final values. This would help determine if it is actually drift rather than randomness. We believe the results of this ILC indicate that phase noise is a viable parameter for future interlaboratory comparisons.

Acknowlegements

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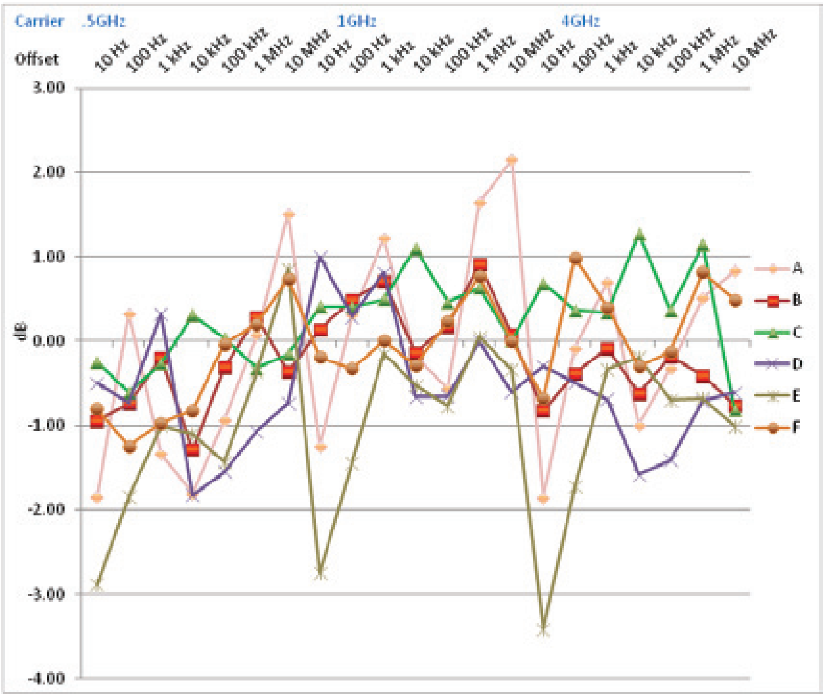

Figure 3. Lab readings minus NIST readings.

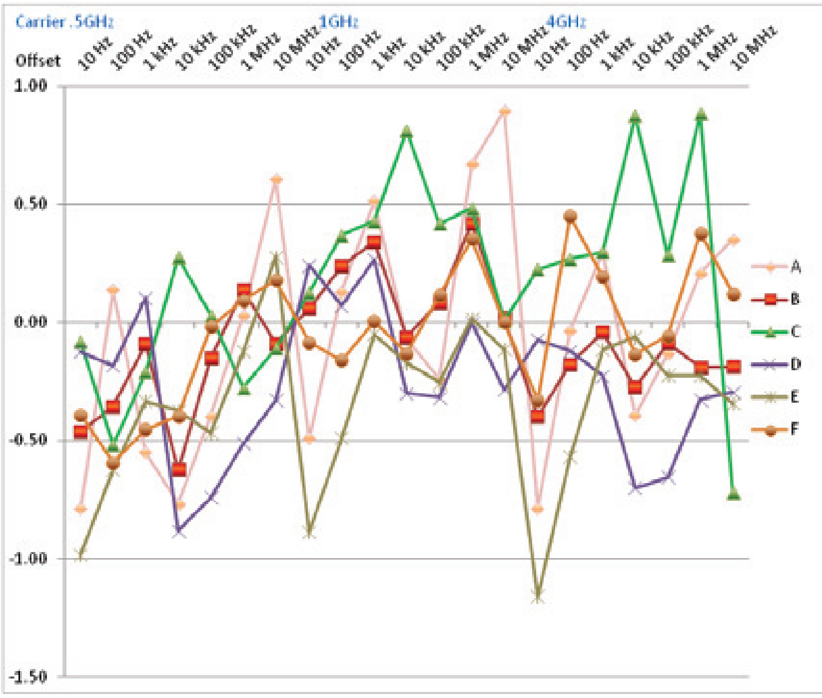

Figure 4. Normalized Error.

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Bart Caswell, Army Primary Standards Lab, bart.l.caswell.civ@mail.mil.

It's a Dynamic World, Now NIST Can Help You Measure Its Changes

From NIST Tech Beat: August 1, 2014

Crash-test dummies, yarn-spinning machines and steel girders in bridges. What do they have in common? Look inside them all and you find transducers, devices that measure the forces that push, pull, weigh upon and slam into them. But transducers also have something in common: Until recently, it was difficult to calibrate them in all but the simplest sense. Now, scientists at the National Institute of Standards and Technology (NIST) are changing that.

If you think of any device with moving parts, it's likely that it's larger, bulkier or heavier than it needs to be, and, therefore, probably requires more energy than it might. That's because engineers have lacked a good way to accurately measure dynamic forces—those that change over time—and so they over-design to compensate. It is difficult to standardize manufacturing and testing processes because measurements made with different transducer models generally do not agree with each other. Fast-changing forces like the shock waves felt in explosions and crashes are particularly difficult to measure accurately.

Chijioke has spent the past few years trying to solve this decades-old problem, and, with his colleagues, has recently finished building the first system that would be widely available to industry that can put a transducer through enough paces to ensure that its force measurements are accurate. Its measurements are tied to the International System of Units (SI), and it is proving useful for exploring how well a transducer functions in a dynamic environment, and for a range of applications.

"Essentially, we place a transducer with a specific amount of weight on top of it onto our device, and then start shaking it," Chijioke says. "We begin vibrating it at 10 times per second, then increase it till it reaches 2,000 times per second. Depending on how thorough a manufacturer wants us to be across a range of weights and frequencies, calibration takes between an hour to a few days."

The new NIST system is similar to a system at the German national metrology institute (Physikalisch-Technische Bundesanstalt, www.ptb.de) and others under development at a few other national metrology institutes, according to Chijioke. NIST intends to use the new system to create a dynamic calibration service that would be more convenient for American manufacturers, who could send their transducers directly to NIST for calibration.

"Calibration might, for example, improve the performance of complex machines that need to work together with others such as robot welders and manufacturing presses on assembly lines," Chijioke says. "But our efforts are likely to have ramifications that we and industry are just beginning to consider. A lot of the issues related to dynamic metrology are currently being worked out, and the field is still developing."

Companies interested in having NIST dynamically calibrate their transducers should contact Rick Seifarth at ricky.seifarth@nist.gov or (301) 975-6652.

Source URL: http://www.nist.gov/pml/div684/force-080114.cfm.

"Two-in-One" Transilluminator

The advanced Spectroline® Bi-O-Vision™ Series transilluminators feature two workstations, producing both 312nm ultraviolet and white light. The TD-1000R model offers fixed-intensity while the TVD-1000R model offers variable-intensity control of either UV or white light. These units are continuously adjustable from 100% down to 50%. This enables life science researchers to select medium wavelength ultraviolet or white light illumination to view fluorescent gels or visible blots.

The UV-B (312nm) intensity of the TVD-1000R can be varied. This flexibility in irradiance control helps ensure the longest sample preparation time, while minimizing actual UV damage to the sample.

The Bi-O-Vision has two adjacent workstations, each with a filter area of 8 x 8" (20 x 20 cm). The UV side is lit by five 8-watt UV-B tubes and delivers nanogram sensitivity for detecting ethidium bromide-stained DNA or RNA. The white light side has three 8-watt fluorescent tubes that ensure excellent illumination for viewing Coomassie blue-stained protein gels, methylene blue-stained DNA gels and autoradiograms.

Website at www.spectroline.com.

Fairview Unveils Complete Family of Low, Medium and High Power Attenuators

Fairview Microwave, Inc. a preeminent supplier of on-demand microwave and RF products, announces the release of their new family of 25, 50 and 100 Watt attenuators with operating frequencies up to 18 GHz depending on the configuration.

There is a total of 236 new part numbers in this attenuator release from Fairview Microwave. Attenuation options include 3 dB, 6 dB, 10 dB, 20 dB, 30 dB, 40 dB, 50 dB and 60 dB models for most connector styles. These attenuators can be ordered with in-series connector configurations including SMA, TNC, Type-N and 7/16 DIN and come in each gender interface including male-male, male-female and female-female.

Fairview's new RF attenuators have average power ratings of 25 Watts, 50 Watts or 100 Watts and a peak power rating of 500 Watts. The 25 Watt versions are bi-directional, while the 50 Watt and 100 Watt models are directional. These attenuators are constructed with black anodized aluminum heatsink bodies and are designed with large cooling fins which aid in heat dissipation at high temperatures. Common applications for these fixed attenuators include power limiting, impedance matching and signal leveling inside RF test systems.

"Our newest lines of 25, 50 and 100 Watt attenuators are an essential addition to our growing portfolio of RF attenuators," explains Greg Arnold, Technical Sales Manager at Fairview Microwave.

Fairview Microwave's family of low, medium and high power attenuators is available from stock and can ship the same-day ordered. For additional details on the expanded line of RF attenuators or company information, please visit http://www.fairviewmicrowave.com/rf-products/25-watt,-50-watt-and-100-watt-attenuators.html. Fairview Microwave can be contacted by phone at +1-972-649-6678.

New R&S CMA180 Radio Test Set

Rohde & Schwarz designed the R&S CMA180 radio test set especially for analog radio production and maintenance. Equipped with a touchscreen for easy operation, the new tester can generate any test signal of up to 20 MHz bandwidth and process high input power levels of up to 150 W. It offers all of the functions of a high end device at an attractive price.

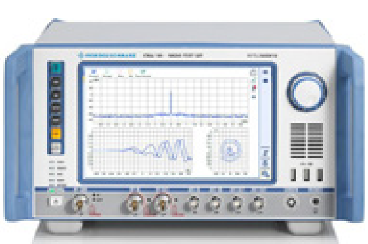
The R&S CMA180 radio test set enables manufacturers and service technicians to test analog radios in the 100 kHz to 3 GHz frequency range. Its large touchscreen and straightforward menu provide for especially simple and fast operation. The R&S CMA180 uses an integrated ARB generator for software implemented test signal generation. Users can generate any output signal with a bandwidth of up to 20 MHz – a feature normally offered only in radiocommunications testers several times more expensive.

The R&S CMA180 is the world's first radiocommunications tester that allows users to generate additional signals with just a few mouse clicks, such as interfering signals for co channel rejection measurements. Service technicians and test engineers can also use the instrument's integrated sequencer to configure and run automatic test sequences.

The R&S CMA180 radio test set is designed for 100 W continuous input power and 150 W peak input power and is the only tester in its price class capable of processing such high input levels. Thanks to digital signal processing, the R&S CMA180 delivers extremely precise measurement results and is ideal for testing software defined radios.

For high precision power measurements, Rohde & Schwarz offers optional extremely linear power sensors that can also be used with the R&S CMA180.

The R&S CMA180 radio test set is now available from Rohde & Schwarz. For details, go to www.rohde-schwarz.com/ad/press/cma180.



Mensor CPA8001 Air Data Test Set with Removable Ps/Qc Sensor

Mensor CPA8001 Air Data Test Set

Mensor recently announced the worldwide release of the CPA8001 Air Data Test Set.

The CPA8001 Air Data Test Set represents the most recent advancement in air data calibration and avionics test equipment. A dual channel altitude and airspeed (Ps/Qc) avionics controller/calibrator, utilizes an advanced needle valve regulator, an intuitive high definition touch screen operator interface, along with high accuracy sensors that deliver an altitude uncertainty of +/- 2.5 ft at sea level and an airspeed uncertainty of +/- 0.05 knots at 500 knots (RVSM compliant). The stand-out features of the CPA8001 are subtle yet impressive, including the ability to emulate the command sets of legacy ADTS units, allowing drop-in compatibility with minimal remote communication programming changes.

Calibration of the all-in-one Ps/Qc sensor is done by addressing the sensor within the CPA8001 chassis through the built-in calibration interface or by removing the sensor for remote calibration to achieve minimal down time. Periodic zeroing of the altitude and the airspeed sensor (Ps/Qc) is done by simply actuating the automated zero sequence, which zeros the Qc sensor at atmospheric pressure and the Ps sensors with an internal high accuracy zero reference sensor.

Many of the features were created through customer evaluation of prototype units to insure that the needs of the operator, the engineer and the programmer were satisfied. All-in-all the CPA8001 is a great choice for laboratory or production calibration and testing of altitude/airspeed indicators and air data computers.

The Fluke Calibration 96270A and 96040A Low Phase Noise RF Reference

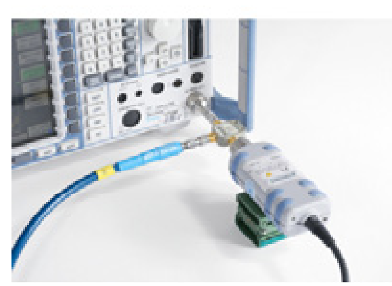
Everett, Wash., Aug. 6, 2014 – Fluke Calibration introduces the 96270A and 96040A Low Phase Noise RF Reference Sources, which simplify RF and microwave calibration systems by replacing many of the instruments and accessories in existing systems. The new reference sources are easy-to-use instruments for calibrating spectrum analyzers, RF power sensors, and more, and because they do the job usually performed by multiple instruments they can cut the cost of RF calibration systems by up to half.

Unlike many RF calibration solutions, the 96270A and 96040A are designed specifically for RF calibration, with a calibration-oriented user interface that makes it easy to learn and operate. They feature "what you set is what you get" accurate signal delivery direct to the UUT input (up to 27 GHz in the 96270A). The integrated frequency counter (300 MHz in the 96270A; 50 MHz in the 96040A) and dual power meter readout in the 96270A eliminate the need for additional instruments.

The 96270A covers more than 80 percent of the test points required for calibrating spectrum analyzer models below 27 GHz, and nearly all spectrum analyzers of any frequency range. "Self-characterization" in the 96270A eliminates the need to perform and apply time-consuming calculations of correction factors for each component in the signal delivery system.

Automated with MET/CAL® Plus Calibration Management Software, the reference sources reduce complexity and calibration times, dramatically improving efficiency and increasing capacity by 50 percent or more over manual and semi-automated methods.

To learn more, visit http://www.flukecal.com/96270A.



Keithley Programmable Power Supplies

CLEVELAND, OH – August 5, 2014 – Keithley Instruments, Inc., a world leader in advanced electrical test instruments and systems, introduced the Series 2280S Precision Measurement, Low Noise, Programmable DC Power Supplies. Unlike conventional power supplies, Series 2280S power supplies are also sensitive measurement instruments with the speed and dynamic range essential for measuring standby current loads and load current pulses that battery-powered wireless, medical, and industrial devices produce. Typical applications include characterizing battery-powered medical devices, wireless sensors, RFID tags, intrinsically safe devices, and consumer electronics, as well as new, low power semiconductor devices.

Series 2280S supplies can output up to 192W of low noise, linear regulated DC power. The Model 2280S-32-6 can output up to 32V at up to 6A, and the Model 2280S-60-3 can output up to 60V at up to 3.2A. Although their sourcing and measurement performance is a step above that of conventional power supplies, Series 2280S supplies have conventional power supply pricing.

These power supplies address emerging trends in the design of electronic components and systems. Manufacturers who want to use the same model of instrument for research, design, and production test will appreciate that the Series 2280S provides an ideal balance of sourcing and measurement capabilities at an easy-to-justify price, allowing them to focus more on new product design and less on their instrumentation.

More information on Series 2280S Precision Measurement, Low Noise, Programmable DC Power Supplies is available at: http://www.keithley.com/data?asset=58094.

Unique Portable Humidity Calibrator from Michell

Rowley, MA: Michell Instruments has upgraded its S503 Portable Humidity Calibrator to include an optional battery pack for customers who need to conduct calibrations at sites without electricity.

The S503 portable humidity calibrator from Michell Instruments is a practical, affordable and flexible solution for calibrating RH sensors. It can be used by most service staff as no special training is necessary. Due to its ease of use, a 3-point calibration can be carried out in about an hour. The S503 in combination with a Michell Chilled Mirror Hygrometer, such as the Optidew Vision, offers a transportable and traceable, total humidity calibration system.

The battery pack provides 12 hours or more of continuous use from a single charge, allowing a full day of calibrations to be completed on-site. This is a unique feature not currently offered for any similar calibrator on the market. The S503 provides true portability, allowing the calibrator to be used where the job is, even if power is not available. http://www.michell.com/us/products/s503.htm.

Spectral Sensing in the Lab or Field from Ocean Optics

Ocean Optics has introduced a new set of spectral sensing tools for researchers in the lab or field. The STS Developers Kit brings together its powerful STS spectrometer, a Raspberry Pi microcomputer, customizable software, and wireless capabilities in single package for integrating spectral sensing quickly and easily. Right out of the box, the kit can be quickly configured for a variety of measurements, cutting set up time and speeding data collection. Lab researchers can use the kit as a platform to build a compact bench-top spectral absorption system, or take advantage of its WiFi connectivity for remote measurements such as plasma emissions inside reactors. Compact and lightweight, the STS is also ideal for field work. It can be bundled as a handheld instrument, used to measure solar irradiance, UV dosimetry, reflected color of plants and animals, volcanic emissions, or water quality. It can be run from a tablet with wireless control or setup as a remote station and run from the lab.

The STS Developer Kit takes advantage of the Raspberry Pi's flexibility and adaptability to enable new uses for spectroscopy. Once connected to a WiFi network, the spectrometer can be controlled through phone, tablet, or computer web browser. The WiFi range is up to 150 m, and all data is securely stored to the onboard SD card.

The web scripting API enables quick development of custom scripts and applications, allowing the STS and Raspberry Pi to perform even more complex tasks. Ocean Optics SeaBreeze drivers communicate directly to the spectrometer via USB interface. A Daemon Service software enables more autonomous functionality as well as coordination with other hardware such as switches or even controlling sampling accessories.

The core of the kit is Ocean Optics' STS microspectrometer. At less than 42 mm square and 24 mm high, the STS delivers maximum power in a small footprint. Its optical design and advanced CMOS detector elevate the STS to performance levels comparable to larger and more expensive spectrometers. To learn more about the STS Development Kit, please contact an Ocean Optics Applications Scientist at info@oceanoptics.com, visit the website at www.OceanOptics.com or call Ocean Optics World Headquarters at +1 727-733-2447.

Transcat Picks Up Speed with New Wind Tunnel Installation

Transcat, Inc. (NASDAQ: TRNS), a leading provider of accredited calibration and compliance services and distributor of professional-grade handheld test, measurement and control instrumentation, announced the installation of the country's largest Westenberg wind tunnel at its Rochester, N.Y. facility. The purchase is consistent with the company's strategy of employing the highest quality assets and capabilities.

"This wind tunnel will allow Transcat to perform all calibrations within our own facility. That means a fast calibration turnaround time on hot wire/vane anemometers, wind speed indicators, balometers and other air velocity devices," said Rainer Stellrecht, vice president of Transcat laboratory operations.

The wind tunnel offers the benefits of greater environmental control and fully accredited calibrations at a higher test uncertainty ratio ("TUR") than leading comparable services. Transcat anticipates adding this capability to their NVLAP scope of accreditation in February 2015.

Key features of the wind tunnel include:

- 0.2 – 66 m/s (30-12,000 FPM) allows for the calibration of a wide range of anemometers, including vane and hot wire
- Accuracy at less than 1.0 percent of reading, for anticipation of test TURs greater than 4:1, minimizing customer risk and providing greater assurance of accuracy

Please visit Transcat.com/AirVelocity for details.

New Video Showcases AMETEK's Custom Power Solutions

Programmable Power (www.programmablepower.com), the global leader in programmable AC and DC power test solutions, has released a short movie highlighting its custom power solution design capabilities for demanding and high-performance power applications. The movie explains how AMETEK helps customers solve their power conversion challenges with quick, safe and cost-effective AC and DC power supply solutions.

The Programmable Power Solutions (PPS) group has been blending this mix in hundreds of applications over the past two decades. With time-to-market and system reliability becoming more important, development teams don't have the luxury to risk development delays while searching for solutions that may already exist. As a trusted power partner, AMETEK's expertise in precision power conversion systems is an effective option for accelerating project development for many applications.

AMETEK PPS designs and manufactures turnkey power solutions, application-specific subsystems and programmable power products—usually within 12 weeks or less. The company adapts its technology to meet special demands in measurement and control, process control and reliability/burn-in. Watch the custom power solutions movie to learn more: http://www.ameteksolutions.com/.

Extended Pressure Range Offered for Additel Gauges and Calibrators

Additel has extended the range of its Digital Pressure Gauge and Digital Pressure Calibrator series products to 40K psi (2800 bar). Prior to this range extension, Additel offered solutions up to 36K psi (2500 bar). This new pressure range is available on the ADT681, ADT680, and ADT672 products. The 40K psi pressure range is also now available for the ADT949 Hydraulic Pressure Pumps.

Additel's new range of products comes in accuracies ranging from 0.025% FS accuracy to 0.25% FS accuracy. Each product comes with a NIST-traceable certificate of calibration.

The Additel 681, 680, 672, and 949 are now available. For more information visit www.additel.com. For information on Additel products and application, or to find the location of your nearest distributor, contact Additel corporation, 22865 Savi Ranch Parkway, Suite F, Yorba Linda, CA 92887, call 1-714-998-6899, Fax 714-998-6999, email sales@additel.com or visit the Additel website at www.additel.com.

Keysight Technologies M8195A

Keysight Technologies, Inc. added a 65-GSa/s, 20-GHz modular instrument to its portfolio of arbitrary waveform generators. The new high-speed, wide-bandwidth M8195A arbitrary waveform generator allows engineers to generate digital, multilevel (e.g. PAM4, MIPI C-PHY) signal scenarios and test their electrical and optical links with complex modulated signals up to 32 GBaud and beyond. This makes the M8195A the most versatile signal generator in the industry.

The instantaneous bandwidth from DC to 20 GHz allows researchers to create extremely short, yet precise pulses. Developers of radar, electronic warfare, satellite and wireless applications can use the M8195A AWG to create wideband signals up to 20 GHz. The instrument delivers high sample rate and wide bandwidth in combination with industry-leading port density. This unique functionality allows engineers to make reliable, repeatable measurements when they are working on binary and multilevel, multichannel digital interfaces as well as coherent optical and wideband communication applications.

The M8195A uses out-of-the box and in-situ calibration and signal predistortion methods to generate exceptionally clean signals – even at the highest data rates. Engineers also can use these techniques to embed or de-embed the channel between the generator and the device under test. The implementation in hardware allows change of parameters at runtime.

With up to 16 GSamples of waveform memory, the M8195A allows designers to create long and highly realistic signal scenarios. Multiple M8195A modules can be combined in a system with up to 16 fully synchronous channels in a single 5-slot AXIe chassis.

The M8195A runs on an AXIe modular system designed for high-performance instrumentation and can be used with a 2-slot or 5-slot chassis.

Shipments for the M8195A arbitrary waveform generator begin Sept. 30 with an entry price of $100,000.

Additional information is available at www.keysight.com/find/M8195A.

Data – The Unrealized Frontier

by Michael Schwartz
Publisher

What can be done with the big data we have been collecting? The metrology industry is sitting on mountains of collected data. So why is it that most of us have yet to find value in our data?

I started thinking about the value of the data, when I thought "how do software companies make money giving their software away?" Somehow, these guys have found value in in their data, data collection and advertising that is greater than the software itself. Companies like ROVIO (the creators of Angry Birds) have converted their business model from selling software to giving it away for free; and surprisingly, they are making good money doing it.

What amazes me is the data they are collecting is largely not real data, like our data. By and large the data they are collecting is metadata—that is, data about data. From this data, they are able to extract details about us, our habits, likes and dislikes, etc.

I was talking to a political consultant in Granville, Ohio, and he was telling me about his company. His company collects data from our phones. They analyze it to determine if we are a swing voter in a swing state. Their mountains of data are able to figure out how to project a 0.6% swing in votes for a specific candidate, based on the weather on voting day.

When I compare the value and accuracy of mountains of calibration data to the data they get from my phone, there is no comparison. I realize it is like comparing apples and oranges, but our calibration data is way more valuable, way more accurate! Our data makes everything in the modern world possible like cell phones, and the cellular networks they run on, possible! So why have we not been able to leverage our data into something of value?

I see several things holding us back as an industry, things I believe are easily correctible, and once corrected, will allow us to leverage the value of our data.

The first one is really simple. We need to start telling the world that we have tons of data. Tell the world we have data, lots and lots of data. Not that we are trying to sell the data, but we should talk about our data like we talk about the weather. Then people will ask us if we can get specific information out of our data? We need to have those conversations with people outside our industry to discover what is hidden in our data.

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The second thing holding us back is a much more difficult problem to resolve and will not happen overnight. As an industry, few of our data systems communicate with each other; our data formats are non-standardized, and many of us have accepted scanning a PDF document and attaching it to a calibration record as the best way to standardize our business process. We need to create or adopt a standard.

The metrology industry needs to either adopt a standard or create one of our own, just like other industries have managed to create standard formats and standards. Unlike other industries, this will be no easy feet; metrology, after all, covers all measurements, all industries, and all levels from the NMI level all the way down to production. The sooner we adopt something, the better off we will be and the sooner we can start utilizing our data.

Then we can start creating analytical tools to scrape some data gathering value from our calibration data. I am not talking about interval analysis tools—I know those tools are already available. I am talking about what is under the iceberg, in other words, what is the hidden value in the data we have amassed.

One good example we could take advantage of could potentially reduce the calibration costs by not performing 100% of the calibration every year. What if we could calibrate some smaller portion of the unit and still maintain its reliability. Often, we as calibration technicians are testing points that never fail, or even seldom fail. We could save our labs' time and money if we could distinguish highly important test points versus test points that seldom fail.

If you step back and think about it, many calibration labs follow the manufacturer's written procedure; most of these manuals were written by an engineer, not a metrologist, when the instrument was being designed. The engineer had access to limited data and time. In many cases, the test points chosen are based on a limited sample set. For many calibration labs, we use this procedure religiously, until the end of time. So, 100 calibrations later or even five or ten years down the road, the calibration lab has amassed ten times more data than the engineer ever had.

Why don't we let the data speak for itself? We have in our hands a gold mine of data, data that tells us what needs to be checked and how often. With a little bit of clever number crunching, we can not only perform interval analysis, but test-point-by-test-point interval analysis. We can save time and money testing high failure points, at every calibration, and low failure points, every other calibration, and even drop some points that never fail on their own. This is nothing new; Fluke did it with their artifact calibration on the 5720's. ❧

SIMPOSIO DE METROLOGÍA 2014

20 ANIVERSARIO CENAM

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October 6th to 10th, 2014

Santiago de Queretaro, Qro. Mexico

TOPICS:

- Metrology in Mexico, challenges and prospects.
- Metrology in the Industry.
- Development of measurement standards and measuring systems.
- Chemical metrology and its applications.
- Metrology on bioanalysis.
- Metrology on nanotechnology.
- Traceability on measurements.
- Uncertainty of measurement.
- Proficiency tests
- Legal Metrology and Standardization
- Metrology in Scientific research
- Metrology in Education

ACTIVITIES:

- Courses (October 6th and 7th).
- Plenary sessions.
- Oral sessions.
- Poster sessions.
- Industrial expo of specialized providers on measuring services and equipment.
- National Meeting on Electrical Metrology (ENME), October 6th and 7th.

On the occasion of the 20th anniversary of CENAM, this edition of the *Simposio de Metrologia* will have the presence of national and international experts on metrology, people of industry, researchers, teaching staff, manufacturers and suppliers of instruments and measurement equipment sharing their experiences and highlighting the meaning of metrology on society and its impact and evolution over the years.

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