CAL LAB

THE INTERNATIONAL JOURNAL OF METROLOGY

METROLOGY 101: Basic Torque Calibration

Wide Band Microwave Noise Measurement System

Accelerate TDR Measurements with Electronic Calibration

Calibrating a UUT on a Remote Computer Using Fluke MET/CAL®

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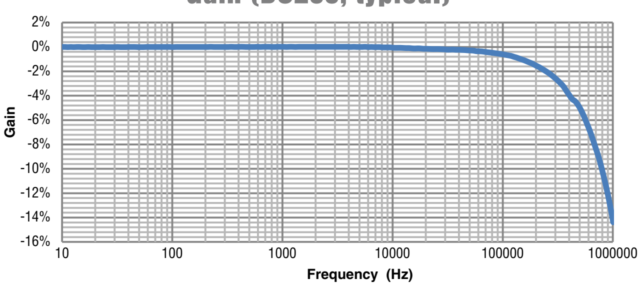
Gain (sensitivity) Error	0.01%	0.5%	20%	0.01%	0.5%	3%	0.01%	0.05%	3%
Phase Error	0.2˚	4˚	30˚	0.1˚	0.5˚	3˚	0.01˚	0.1˚	1˚

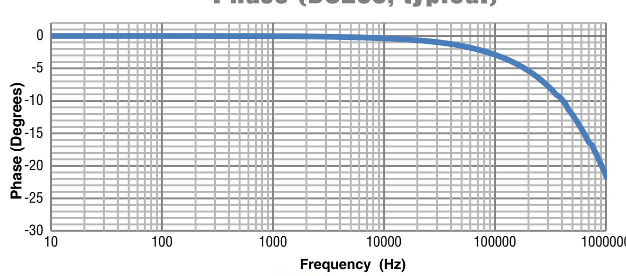
† Voltage Output options available in ±1V and ±10V

Gain / Phase

Gain (DS200, typical)



Phase (DS200, typical)



DSSIU-4 for Multi Channel Systems

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- Heads may be mixed (e.g.: One DS2000 Head and three DS200 Heads)

DSSIU-4

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CALENDAR

UPCOMING CONFERENCES & MEETINGS

Nov 19-20, 2014 Large Volume Metrology Conference & Exhibition (LVMC). Manchester, UK. The LVMC is the only European event solely dedicated to portable and large volume 3D measurement technology. http://www.lvmc.eu/.

Dec 2-5, 2014 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/.

Feb 11-15, 2015 NCSLI Technical Exchange. Raleigh, NC. Offering measurement training workshops, conducted by True Experts in the field of metrology. http://ncsli.org.

Mar 2-5, 2015 - 15th International Conference on Metrology and Properties of Engineering Surfaces. University of North Carolina at Charlotte is home to the Center for Precision Metrology, an interdisciplinary association of faculty and student researchers, allied with industrial partners in the research, development and integration of precision metrology as applied to manufacturing. http://aspe.net/metprops2015.html.

Mar 3-4, 2015 South East Asia Flow Measurement Conference. Kuala Lumpur, Malaysia. The 2015 South East Asia Flow Measurement Conference will continue to meet challenges of the oil and gas industry by staying ahead of developments in technology, regulation and practice. http://www.tuvnel.com/.

Mar 17-18, 2015 METROMEET. Bilbao, Spain. The International Conference of Industrial Dimensional Metrology. http://metromeet.org.

Mar 17-19, 2015 European Flow Measurement Workshop. Noordwijk, Netherlands. Previously held in Portugal, this year's 3rd annual workshop will take place in the Grand Hotel Huis ter Duin. http://www.efmws.eu/.

Mar 18-20, 2015 Measurement Science Conference (MSC) & Training Symposium. Anaheim, CA. "Engaging Measurement Science to Inspire Organizational Excellence" for 45 years. http://msc-conf.com.

Mar 20-22, 2015 A2LA Technical Forum & Annual Meeting. Baltimore, MD. http://www.a2la.org/techforum.

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EDITOR'S DESK

Take a Trip

I spent the past month organizing notes on meetings & conferences for 2015. Some events come and go, but many take place regularly across the globe—from Moscow, Russia to Grapevine, Texas. Maybe you've never attended or just not attended in awhile. If that's you, then consider taking a trip.

Conferences and meetings are avenues for people to share innovations and bounce ideas off each other. Attendees can pick and choose their experience: training & education, meeting and drinking with other attendees in and around the venue, touching basis with commercial partners for the first time, or browsing the exhibit floor. The online experience can be cheap and practical, but there's incredible value in experiencing a live event, complete with face-to-face interaction and participation. Attending a live event also helps to keep such activities going, making it a win-win for both the participant and industry as a whole.

Cal Lab Magazine has conferences to thank for helping to find articles, advertisers, and collaborative relationships... *almost* all the elements needed to build, promote, and sustain the publication. Online and in print, Cal Lab Magazine provides information on various conferences & meetings happening throughout the US and countries around the globe. If you haven't paid much attention before, check out the calendar section starting on page 2—it's there in each and every printed issue. Every event has a URL you can visit to find further information such as training abstracts, topics covered, and pricing.

If I haven't even made you curious about our industry events, then at least take note of this issue's line-up of articles, starting with "Metrology 101: Basic Torque Calibration," where author Jerry Eldred presents to us a wealth of tips for calibration of torque tools. Our friends in Turkey brought us an article on "Wide Band Microwave Noise Measurement System" by Murat Celep at TUBITAK, while the folks at Keysight Technologies explain in detail their technology to "Accelerate TDR Measurements with Electronic Calibration." Finally, our publisher and software engineer extraordinaire included his paper, "Calibrating a UUT on a Remote Computer Using Fluke MET/CAL®," previously presented at this year's Measurement Science Conference (MSC) in Anaheim, California.

Happy Measuring,

Sita Schwartz
Editor

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.

Instrumentation for Test and Measurement – OnDemand Complete Internet Course. Technology Training, Inc. (TTI), http://pubs.ttiedu.com/?q=course_list.

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

Metrology Concepts – OnDemand Complete Internet Course. Technology Training, Inc. (TTI), http://pubs.ttiedu.com/?q=course_list.

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.

The Uncertainty Analysis Program. Learning Measure. http://www.learningmeasure.com/.

CALENDAR

SEMINARS: Dimensional

Nov 20-21, 2014 Gage Calibration Systems and Methods. Mason (Cincinnati), OH. Mitutoyo Institute of Metrology. http://www.mitutoyo.com/support/mitutoyo-institute-of-metrology/.

Nov 20-21, 2014 Hands-On Gage Calibration and Repair Workshop. Detroit, MI. IICT Enterprises LLC. http://www.iictenterprisesllc.com/.

Dec 4-5, 2014 Hands-On Gage Calibration and Repair Workshop. Schaumburg, IL. IICT Enterprises LLC. http://www.iictenterprisesllc.com/.

Dec 4-5, 2014 Gage Calibration Systems and Methods. Aurora (Chicago), IL. Mitutoyo Institute of Metrology. http://www.mitutoyo.com/support/mitutoyo-institute-of-metrology/.

Jan 6-7, 2015 Hands-On Gage Calibration and Repair Workshop. Detroit, MI. IICT Enterprises LLC. http://www.iictenterprisesllc.com/.

Jan 15-16, 2015 Gage Calibration Systems and Methods. Houston, TX. Mitutoyo Institute of Metrology. http://www.mitutoyo.com/support/mitutoyo-institute-of-metrology/.

Jan 20-21, 2015 Hands-On Gage Calibration and Repair Workshop. Milwaukee, WI. IICT Enterprises LLC. http://www.iictenterprisesllc.com/.

Jan 27-29, 2015 Hands-On Gage Calibration. Aurora, IL. Mitutoyo Institute of Metrology. http://www.mitutoyo.com/support/mitutoyo-institute-of-metrology/.

Feb 3-4, 2015 Hands-On Gage Calibration and Repair Workshop. Maple Grove, MN. IICT Enterprises LLC. http://www.iictenterprisesllc.com/.

Feb 11, 2015 Dimensional Measurements in an Industrial Testing Environment. Raleigh, NC. NCSLI Technical Exchange, http://www.ncsli.org/.

Feb 19-20, 2015 Hands-On Gage Calibration and Repair Workshop. Yorba Linda, CAl IICT Enterprises LLC. http://www.iictenterprisesllc.com/.

Mar 5-6, 2015 Gage Calibration Systems and Methods. City of Industry, CA. Mitutoyo Institute of Metrology. http://www.mitutoyo.com/support/mitutoyo-institute-of-metrology/.

Mar 17-19, 2015 Hands-On Gage Calibration. Aurora, IL. http://www.mitutoyo.com/support/mitutoyo-institute-of-metrology/.

CALENDAR

SEMINARS: Electrical

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

Feb 11, 2015 Precision DMM Measurements. Raleigh, NC. NCSLI Technical Exchange, http://www.ncsli.org/.

Feb 12, 2015 Basic Electrical Metrology Techniques. Raleigh, NC. NCSLI Technical Exchange, http://www.ncsli.org/.

Apr 20-23, 2015 MET-101 Basic Hands-on Metrology. Everett, WA. Fluke Calibration. http://us.flukecal.com/training/courses/MET-101.

May 18-21, 2015 MET-301 Advanced Hands-on Metrology. Everett, WA. Fluke Calibration. http://us.flukecal.com/training/courses/MET-301.

SEMINARS: Flow & Pressure

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

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

Dec 2, 2014 Fundamentals of Flow Measurement Training Course. Aberdeen, Scotland. http://www.tuvnel.com/.

Feb 11, 2015 Industrial Pressure Calibration and Measurements. Raleigh, NC. NCSLI Technical Exchange, http://www.ncsli.org/.

Feb 23-27, 2015 Principles of Pressure Calibration. Phoenix, AZ. Fluke Calibration. http://us.flukecal.com/Principles-of-Pressure.

Mar 19, 2015 Measurement Uncertainty Analysis of Liquid Mass Flow Rigs. Anaheim, CA. http://msc-conf.com/tutorial-schedule/.

Mar 19, 2015 Measurement Uncertainty Analysis of a Coriolis Mass Flow Meter. Anaheim, CA. http://msc-conf.com/tutorial-schedule/.

Apr 20-24, 2015. Advanced Piston Gauge Metrology. Phoenix, AZ. Fluke Calibration. http://us.flukecal.com/training.

May 18-22, 2015 Principles of Pressure Calibration. Phoenix, AZ. Fluke Calibration. http://us.flukecal.com/Principles-of-Pressure.

CALENDAR

SEMINARS: General

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

Jan 26-30, 2015 Fundamentals of Metrology. Gaithersburg, MD. http://www.nist.gov/pml/wmd/labmetrology/training.cfm.

Feb 9-13, 2015 Fundamentals of Metrology. Gaithersburg, MD. http://www.nist.gov/pml/wmd/labmetrology/training.cfm.

Feb 12, 2015 Process Calibration. Raleigh, NC. NCSLI Technical Exchange, http://www.ncsli.org/.

Mar 2-6, 2015 Fundamentals of Metrology. Gaithersburg, MD. http://www.nist.gov/pml/wmd/labmetrology/training.cfm.

Mar 18, 2015 Back to Basics: Metrology 101. MSC Tutorial, Anaheim, CA. http://msc-conf.com/tutorial-schedule/.

Mar 19, 2015 DIY Statistics: A Statistics Refresher for Metrologists. MSC Tutorial, Anaheim, CA. http://msc-conf.com/tutorial-schedule/.

Apr 7-9, 2015 Instrumentation for Test and Measurements. Las Vegas, NV. http://www.ttiedu.com/schedule.html.

SEMINARS: Mass

Mar 16-27, 2015 Mass Metrology Seminar. Gaithersburg, MD. NIST / Office of Weights and Measures. http://www.nist.gov/pml/wmd/labmetrology/training.cfm.

Mar 19, 2015 The Correct Assessment of a Weighing Instrument. MSC Tutorial, Anaheim, CA. http://msc-conf.com/tutorial-schedule/.

SEMINARS: Measurement Uncertainty

Nov 17-18, 2014 Introduction to Measurement Uncertainty. San Diego, CA. American Association for Laboratory Accreditation, http://www.a2la.org/training/course_schedule.cfm.

Feb 11, 2015 Calculating Uncertainties in Testing Laboratories. Raleigh, NC. NCSLI Technical Exchange, http://www.ncsli.org/.

CALENDAR

Feb 12, 2015 Statistical Analysis of Metrology Data. Raleigh, NC. NCSLI Technical Exchange, http://www.ncsli.org/.

Mar 19, 2015 Practical Uncertainty for the Average and Not So Average Calibration Laboratory. MSC Tutorial, Anaheim, CA. http://msc-conf.com/tutorial-schedule/.

SEMINARS: Microwave

March 19, 2015 Microwave Measurement Basics. MSC Tutorial, Anaheim, CA. http://msc-conf.com/tutorial-schedule/.

SEMINARS: Quality & Standards

Dec 8-9, 2014 ISO/IEC 17025:2005 and Laboratory Accreditation. Frederick, MD. http://www.a2la.org/training/course_schedule.cfm

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

Feb 11, 2015 Asset Management in a Test Lab Environment. Raleigh, NC. NCSLI Technical Exchange, http://www.ncsli.org/.

Feb 11, 2015 Record-Keepers and Record Seekers: Common Record-Keeping Mistakes. Raleigh, NC. NCSLI Technical Exchange, http://www.ncsli.org/.

Feb 11-12, 2015 ISO/IEC 17025 Laboratory Accreditation. Raleigh, NC. NCSLI Technical Exchange, http://www.ncsli.org/.

Feb 12, 2015 Proficiency Testing. Raleigh, NC. NCSLI Technical Exchange, http://www.ncsli.org/.

Feb 12, 2015 Selecting Appropriate Calibration Intervals. Raleigh, NC. NCSLI Technical Exchange, http://www.ncsli.org/.

Mar 18-19 Preparation for ASQ Certified Calibration Technician Exam Refresher Workshop. MSC Tutorial, Anaheim, CA. http://msc-conf.com/tutorial-schedule/.

Mar 18, 2015 Root Cause Analysis. MSC Tutorial, Anaheim, CA. http://msc-conf.com/tutorial-schedule/.

Mar 19, 2015 Aligning Supplier Quality with ASQ Quality Tools and Lean Six Sigma Methodologies. Anaheim, CA. http://msc-conf.com/tutorial-schedule/.

Mar 19, 2015 Metrology and Quality Control in Nanotechnology. MSC Tutorial, Anaheim, CA. http://msc-conf.com/tutorial-schedule/.

Mar 19, 2015 RACI for Process and Procedures Management in an ISO 17025, ISO 9001, and NQA-1 Environment. MSC Tutorial, Anaheim, CA. http://msc-conf.com/tutorial-schedule/.

CALENDAR

Mar 19, 2015 Risk Management for Process Improvement in the Calibration & Testing Laboratory. MSC Tutorial, Anaheim, CA. http://msc-conf.com/tutorial-schedule/.

Mar 19, 2015 Traceability and Uncertainty Policies of the International Laboratory Accreditation Cooperation (ILAC). MSC Tutorial, Anaheim, CA. http://msc-conf.com/tutorial-schedule/.

SEMINARS: Software

Dec 8-12, 2014 Basic MET/CAL® Procedure Writing. Everett, WA. Fluke Calibration, http://us.flukecal.com/software-training.

Feb 11-12, 2015 An Intro to Instrument Control and Calibration Automation in LabVIEW™. Raleigh, NC. NCSLI Technical Exchange, http://www.ncsli.org/.

SEMINARS: Temperature

Feb 11, 2015 Thermocouple Theory and Practical Application. Raleigh, NC. NCSLI Technical Exchange, http://www.ncsli.org/.

Feb 12, 2015 Temperature Measurement/Temperature Metrology and Thermometer Calibration. Raleigh, NC. NCSLI Technical Exchange, http://www.ncsli.org/.

Mar 19, 2015 Tips and Tricks in Temperature Uniformity Surveys. MSC Tutorial, Anaheim, CA. http://msc-conf.com/tutorial-schedule/.

Apr 14-16, 2015 Principles of Temperature Metrology. American Fork, UT. Fluke Calibration. http://us.flukecal.com/training/courses/Principles-Temperature-Metrology.

SEMINARS: Vibration

Dec 1-4, 2014 Fundamentals of Vibration for Test & Design Applications. Las Vegas, NV. http://www.ttiedu.com/schedule.html.

Feb 12, 2015 Dynamic Sensors & Calibration. Raleigh, NC. NCSLI Technical Exchange, http://www.ncsli.org/.

Mar 10-12, 2015 Fundamentals of Vibration for Test Applications. Las Vegas, NV. http://www.ttiedu.com/schedule.html.

Apr 6-8, 2015 Random Vibration and Shock Testing. Santa Clarita, CA. http://www.equipment-reliability.com.

SEMINARS: Volume

Feb 12, 2015 Minimizing Sources of Error in Pipetting. Raleigh, NC. NCSLI Technical Exchange, http://www.ncsli.org/.

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

World's First Photonic Pressure Sensor Outshines Traditional Mercury Standard

October 29, 2014—For almost 400 years, mercury gauges have prevailed as the most accurate way to measure pressure. Now, within weeks of seeing "first light," a novel pressure-sensing device has surpassed the performance of the best mercury-based techniques in resolution, speed, and range at a fraction of the size. The new instrument, called a fixed-length optical cavity (FLOC), works by detecting subtle changes in the wavelength of light passing through a cavity filled with nitrogen gas.

The FLOC system is poised to depose traditional mercury pressure sensors – also called manometers – as the standard used to calibrate commercial equipment, says the interdisciplinary team of NIST researchers* who developed the system and will continue to refine it over the next few years. The new design is also a promising candidate for a factory-floor pressure instrument that could be used by a range of industries, including those associated with semiconductor, glass, and aerospace manufacturing.

"We've exceeded the expectations we had three years ago," says Thermodynamic Metrology Group Leader Gregory Strouse. "This device is not only a photonic sensor, it's also a primary standard. It's the first photonic-based primary pressure standard. And it works."

About the size of a travel mug, the FLOC has a resolution of 0.1 mPa (millipascal or thousandths of a pascal), 36 times better than NIST'S official U.S. pressure standard, which is a 3-meter-tall (about 10-foot) column of liquid mercury that extends through the ceiling of the calibration room.

The cavity's range also beats that of the mercury manometer at the low end, "an impressively wide range" that stretches from the millipascal- to hundred thousand pascal-level, says Principal Investigator Jay Hendricks of the Thermodynamic Metrology Group. "There's no other instrument that can handle so many different ranges and have that high a resolution," he continues.

The FLOC is 100 times faster than the standard mercury manometer, too.

"It can do in a second what the big mercury manometer takes about a minute and a half to do," Hendricks says.

Traditional pressure sensors rely on changes to the height of a column of mercury, which rises or falls in response to pressure. But though accurate and reliable, these instruments are bulky and their dependence on mercury, a neurotoxic substance, makes them undesirable. In fact, mercury's hazards have prompted a global effort to cut or phase out this substance from products and manufacturing, a goal made manifest by a United Nations Environment Program (UNEP) treaty that has been signed by more than 100 countries.

The new, mercury-free, photonic pressure sensor consists of a temperature-controlled optical cavity approximately 15.5 cm (about 6 inches) long by 5 cm (2 in) by 5 cm (2 in) encased in copper. The cavity contains two channels, one flooded with nitrogen gas and the other in vacuum. A beam of low-power red (633-nm) laser light is "locked" to each channel, meaning it forms a standing wave that self-synchronizes through constant adjustments to its wavelength. Some of the light from each channel is allowed to exit the FLOC, where the beams combine to form an interference pattern.

A change in pressure does not affect the light in the vacuum tube because there is no medium to be affected. But it does affect the density of the nitrogen, which in turn alters the gas's index of refraction or how fast light travels through it. And this change in light speed affects the wavelength of the light resonating in the nitrogen-filled channel. Though these alterations in wavelength are minute – on the picometer level, a hundred times smaller than an atom – they can be detected in the interference pattern.

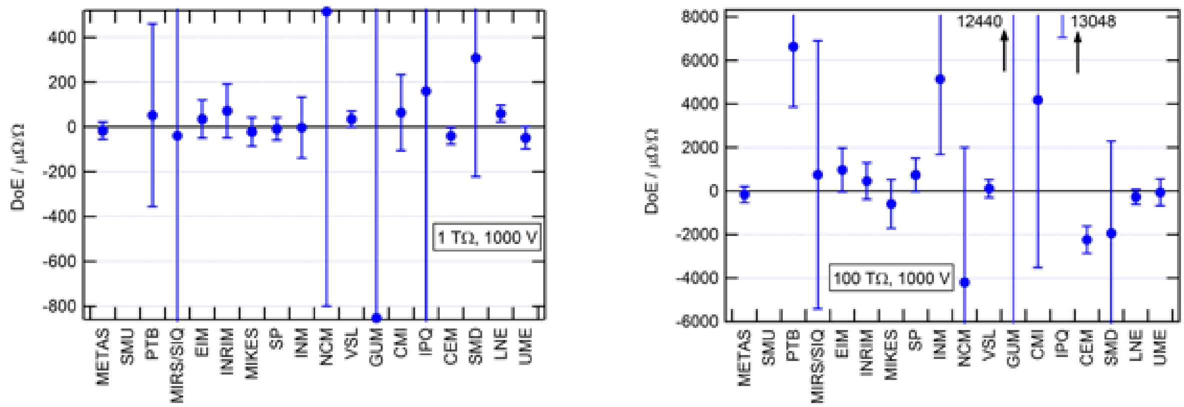
So far the technique is accurate to within 0.005% or 50 parts per million (ppm), which makes it superior to most commercial pressure instruments. But this is only a first attempt and Hendricks and his colleagues believe they can do better. In the next three years, the team will try to drive this accuracy below the 5 ppm range, which will allow it to surpass that of the current manometer standard.

Hendricks and Strouse see great potential for making the system smaller too – perhaps as small as a smartphone someday – while further increasing its speed and resolution. "There are tricks we haven't even begun to tap into yet," Hendricks says.

— Jennifer Lauren Lee

*A collaboration between the PML Thermodynamic Metrology and Dimensional Metrology groups.

Source: NIST Physical Measurement Laboratory, Sensor Science Division (http://www.nist.gov/pml/div685/grp01/102814-pressuresensor.cfm).



Degrees of equivalence (DoE) with respect to the comparison reference value for 1 TW (left) and 100 TW (right) resistance.

Resistance at the Highest Level: Results of a European Comparison

High-ohmic resistance measurements are an important part of the calibrations performed by national metrology institutes (NMIs) in Europe. High-ohmic resistors are among others used in instruments measuring electric isolation characteristics of materials, such as teraohmmeters, and in electrometers and picoammeter for the measurement of small electrical currents.

The techniques used to measure very high resistance values differ quite substantially from the calibration techniques applied in the lower resistance ranges. For this reason, for the first time in Europe a comparison was organised of 1 TΩ and 100 TΩ resistance using a set of well characterized travelling standards.

The results of the comparison for most of the 18 participants agree reasonably well with the comparison reference value. Some travelling standard resistors showed stability problems which was difficult to model, and put some limitations on the meaningfulness of the comparison results for the laboratories with the best uncertainties.

A remarkable outcome is the big difference in the uncertainty statements made by the participants, even in cases where similar measurement systems were used. This indicates that some spurious effects such as leakage or insufficient stabilization time have remained undetected by some participants and/or that their effect on the total measurement uncertainty has been underestimated. Here the results of the comparison help the participants to critically review their measurement procedures and uncertainty models.

For further information contact Beat Jeckelmann, beat.jeckelmann@metas.ch, or Gert Rietveld, grietveld@vsl.nl

The full comparison report can be found on http://iopscience.iop.org/0026-1394/50/1A/01008/ .

Trouble with a Capital 'G'

October 27, 2014 - NIST has taken part in a new push to address a persistent and growing problem in physics: the value of *G*. The Newtonian constant of gravitation, used to calculate the attractive force of gravity between objects, is more than 300 years old. But although scientists have been trying to measure its value for centuries, *G* is still only known to 3 significant figures. By contrast, other constants have been measured with much greater precision; the mass of the electron in kilograms, for example, is known to about 8 digits.[i]

Worse yet, the more experiments researchers conduct to pin down the gravitational constant, the more their results diverge.

On October 9-10, 2014, several dozen scientists from around the world gathered at NIST to consider their options.

"We're all here because we have a problem with *G* – and I mean, boy, do we have a problem with *G*," said Carl Williams, Chief of PML's Quantum Measurement Division, to the assembled group on the first morning of the meeting. "This has become one of the serious issues that physics needs to address."

The gravitational constant is familiarly known as "big *G*" to distinguish it from "little *g*," the acceleration due to the Earth's gravity.[ii] Despite its name, big *G* is tiny – about 6.67 x 10^{-11} m^3 kg^{-1} s^{-2} – and comparatively feeble, roughly a trillion trillion trillion times weaker than the electromagnetic force responsible for affixing souvenir magnets to refrigerators. And its weakness makes it difficult to measure.

Experimentalists have used a variety of approaches – swinging pendulums, masses in freefall, balance beams, and torsion balances that measure the torque or rotation of wires supporting masses that are attracted to other masses. But a plot of all the results from the past 15 years reveals a relatively wide spread in values ranging from about 6.670 x 10^{-11} m^3 kg^{-1} s^{-2} to 6.676 x 10^{-11} m^3 kg^{-1} s^{-2}.

Furthermore, CODATA – the International Council for Science Committee on Data for Science and Technology, which analyzes the results of individual experiments and provides an internationally accepted sets of values for fundamental physical constants – has had to increase the uncertainty on its latest recommendation for a value of *G* due to the divergence of the experiments.[iii]

At the NIST workshop, the 53 participants agreed unanimously that something should be done. They recommended that one or more organizations establish annual or biannual meetings focused specifically on the campaign to determine big *G*'s value with greater accuracy, and they supported the idea of focusing on new approaches to the measurement, such as the atomic interferometry setup used in a recent experiment involving laser-cooled rubidium atoms.[iv]

The main culprit in these discrepancies is suspected to be systematic uncertainties in the measurements, and much of the discussion focused on reducing noise. One way to address this problem, participants felt, is for different teams to conduct independent experiments using the same set of apparatus. Two groups with particularly deviant results offered their equipment during the meeting, pending discussions with the teams that will reuse the resources.

Workshop attendees expressed moderate interest in forming a consortium, an organization that would centralize the process of finding consensus. A potential benefit of a consortium would be providing NIST and other National Measurement Institutes (NMIs) with a means of contributing support, for example in the form of precision length metrology services, to members.

"Clearly, there is no right answer for how to move forward," Williams said. "But there is international support around resolving the big *G* controversy, and so it's a great time for us in that regard."

-- Jennifer Lauren Lee

Credit: PML/Jenny Lee

[i] The mass of an electron is 9.109 382 91(40) x 10^{-31} kg, where the number in parentheses indicates uncertainty in the final two digits.

[ii] Calculating the gravitational attraction between two objects requires taking the product of two masses and dividing by the square of the distance between them, then multiplying that value by *G*. The equation is $F=Gm_1m_2/r^2$.

[iii] CODATA's latest set, released in 2010, recommended a value for *G* of 6.673 84(80) x 10^{-11} m^3 kg^{-1} s^{-2} compared to its previous result from 2006 of 6.674 28(67) x 10^{-11} m^3 kg^{-1} s^{-2}. The values in parentheses indicate standard uncertainty (based on standard deviation), in this case plus or minus 0.000 80 x 10^{-11} m^3 kg^{-1} s^{-2} and plus or minus 0.000 67 x 10^{-11} m^3 kg^{-1} s^{-2} respectively.

[iv] In this experiment, researchers pushed two clouds of cold rubidium atoms into a vacuum chamber with laser light. The atoms accelerated differently depending on the placement of high-density masses (tungsten weights totaling about 500 kg) arranged in various configurations. Differences in acceleration due to the atoms' gravitational attraction to the tungsten masses could be picked up in the clouds' interference pattern. G. Rosi, F. Sorrentino, L. Cacciapuoti, M. Prevedelli and G.M. Tino. Precision measurement of the Newtonian gravitational constant using cold atoms. *Nature.* Vol. 510. 518–521. June 26, 2014. DOI:10.1038/nature13433

Source: NIST Physical Measurement Laboratory, Quantum Measurement Division (http://www.nist.gov/pml/div684/102714-bigg.cfm).

NIST Quantum Probe Enhances Electric Field Measurements

Researchers at the National Institute of Standards and Technology (NIST) and the University of Michigan have demonstrated a technique based on the quantum properties of atoms that directly links measurements of electric field strength to the International System of Units (SI).*

The new method could improve the sensitivity, precision and ease of tests and calibrations of antennas, sensors, and biomedical and nano-electronic systems and facilitate the design of novel devices.

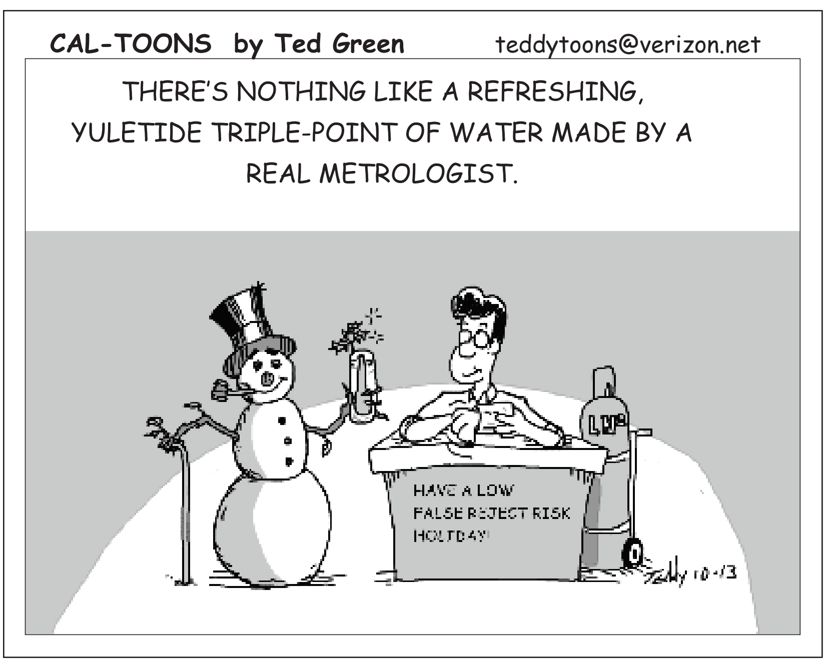
Conventional electric field probes have limited frequency range and sensitivity, often disturb the field being measured, and require laboratory calibrations that are inherently imprecise (because the reference field depends on the geometry of the source). Furthermore, linking these measurements to SI units, the highest level of calibration, is a complex process.

NIST's new electric-field probe spans enormous ranges. It can measure the strength of fields from 1 to 500 gigahertz, including the radio, microwave, millimeter-wave and sub-terahertz bands. It can measure fields up to 100 times weaker than conventional methods can (as weak as 0.8millivolts per meter, the SI unit of measure). Researchers used the new method to measure field strengths for a wide range of frequencies, and the results agreed with both numerical simulations and calculations.

Importantly, the new method can calibrate itself, as well as other instruments, because it is based on predictable quantum properties: vibrations in atoms as they switch between energy levels. This self-calibration feature improves measurement precision and may make traceable calibrations possible in the millimeter and sub-terahertz bands of the spectrum for the first time.

"The exciting aspect of this approach is that an atom is rich in the number of transitions that can be excited," NIST project leader Chris Holloway says. "This results in a broadband measurement probe covering a frequency range of 1 to 500 gigahertz and possibly up to 1 terahertz."

The NIST instrument currently is tabletop sized, but researchers are working on miniaturizing it using photonic structures.



The basic method has already been demonstrated for imaging applications.** Briefly, researchers use a red and a blue laser to prepare atoms contained in a cylinder to high-energy ("Rydberg") states, which have novel properties such as extreme sensitivity and reactivity to electromagnetic fields. An antenna or other source generates an electric field, which, depending on its frequency, affects the spectrum of light absorbed by the atoms. By measuring this effect, researchers can calculate the field strength. Various atoms can be used—NIST uses rubidium or cesium—to measure field strength in different parts of the frequency spectrum.

Among possible applications, the NIST probe may be suitable for measuring and optimizing compatibility in densely packaged electronics that include radar and wireless communications and control links, and for integration into endoscopic probes with medical applications such as investigating implants in the body. The technique might also be included in a future "NIST on a chip" offering multiple measurement methods and standards in a portable form.

Importantly, the technique also enables, for the first time, calibrated measurements of frequencies above 100 GHZ, in the millimeter wave and sub-terahertz bands.*** This capability will be crucial for the development of advanced communications systems and climate change research, among other applications.

Five co-authors of the new paper are with the University of Michigan, which provided the blue laser and aided in the experiments. The project is funded in part by the Defense Advanced Research Projects Agency.

* C.L. Holloway, J.A. Gordon, S. Jefferts, A. Schwarzkopf, D. A. Anderson, S.A. Miller, N. Thaicharoen and G. Raithelet. Broadband Rydbergatom-based electric-field probe: From self-calibrated measurements to sub-wavelength imaging. IEEE Trans. on Antennas and Propagation. 99. Accepted for publication. DOI: 10.1109/TAP.2014.2360208.

** See 2014 NIST Tech Beat article, "NIST Technique Could Make Sub-wavelength Images at Radio Frequencies," at www.nist.gov/pml/electromagnetics/subwave-061714.cfm.

*** J.A. Gordon, C.L. Holloway, A. Schwarzkopf, D. A. Anderson, S. Miller, N. Thaicharoen and G. Raithel. Millimeter wave detection via Autler-Townes splitting in rubidium Rydberg atoms. Applied Physics Letters, 2014. Vol. 105, Issue 2.DOI:10.1063/1.4890094.

Source: *Tech Beat* - October 7, 2014, http://www.nist.gov/public_affairs/tech-beat/tb20141007.cfm.

Frost & Sullivan: Functionality in Test Instrumentation Software

With the rapid emergence of new technologies, the demand for simple and easy-to-use solutions has grown in the global instrumentation software market. Acknowledging this need, instrumentation software companies are focusing on simplifying complicated technical tasks and processes as well as adding new functionalities.

New analysis from Frost & Sullivan, *It's All About Software -- Analysis of the Market for Global Instrumentation Software and Software Solutions for General Purpose Test Instrument*, finds that the market earned revenues of $1.52 billion in 2013 and estimates this to reach $2.21 billion in 2018.

The functionality of instrumentation software has evolved throughout the last decade, with many software developers employing powerful formulas, advanced rendering, and intuitive user interfaces.

"The close integration of electronic test equipment and software is resulting in improved efficiency of the overall system," said Frost & Sullivan Measurement & Instrumentation Industry Analyst Prathima Bommakanti. "The faster changeover, enhanced accuracy, and higher placement rates will all help deliver greater production yields to customers."

Investments in R&D will give a significant boost to the participants at a time when market maturity and the economic downturn are limiting the sales of associated software. However, superior customer awareness and competitive prices are generating interest in add on and turnkey software.

Another important trend in the test instrumentation software market is the increasing heterogeneity in product/application mix at customer locations. Due to the resulting need for several types of software/products, customers tend to gravitate towards single-source suppliers that can provide the packages/services by themselves or through partnerships.

End users' preference for a one-stop-shop drives equipment vendors to provide the equipment in a manner that eliminates the need to procure software individually. They also tend to offer free updates of the software if there is no revision in its version.

"With the increase in complexity of DUT, customers in the global instrumentation software market are in a constant search for simple and easy-to-use solutions," noted Bommakanti. "Identifying this need, market participants are striving to ensure that their software offer high ease-of-use to their customers."

If you are interested in more information on this study, please send an email to Julia Nikishkina, Corporate Communications, julia.nikishkina@frost.com, with your full name, company name, job title, telephone number, company email address, company website, city, state and country.

It's All About Software -- Analysis of the Market for Global Instrumentation Software and Software Solutions for General Purpose Test Instrument is part of the Test & Measurement (http://www.testandmeasurement.frost.com) Growth Partnership Service program.

Basic Torque Calibration

By Jerry L. Eldred
TESCOM

Introduction

The need for accurate torque measurement spans technologies and industries from missions to Mars, to installing lug nuts on your old pickup truck. When torque is correct, it makes us safer, and helps equipment operate properly. When it is not correct, however, bolts can snap, wheels can fall off, gaskets can burst and many dangerous things can happen. A recent survey of automotive service managers found that 23% of all auto service problems could be traced to incorrect torque.

First understood by Archimedes with his laws of levers, torque is most simply described as the rotational or angular or twisting force which tends to cause a change in rotational motion. It is the amount of force applied to a lever arm in relation to a fulcrum (axis). Mathematically, it is defined as the amount of force applied multiplied by the distance (length of the lever arm) along the lever to the point where the rotational force is applied.

One noteworthy aspect of torque in mechanical connections is its relationship to friction. For example, a lug nut may be designed to securely attach a wheel at a given torque. As the lug nut is tightened, it presses with increasing force against the wheel; which increases both friction and the torque needed to tighten it further. Since the amount of friction (and subsequent torque) is a coefficient of the materials used, if a lubricant is applied between the lug nut and wheel, the friction and torque would be reduced. So with the same amount of applied force (torque), due to the reduced friction, the lug nut would be over tightened, and in some cases bolts might even be snapped. This example underscores the complex nature of torque. It really isn't simple; and in calibrating torque tools, it is important to understand and account for its many variables.

Figure 1. Typical torque calibration system.

Calibrating torque tools would seem simple. But many metrology professionals agree that among thousands of calibration disciplines, torque may be the most susceptible of them all to technique. So understanding and using some basic techniques in the calibration process may make the difference whether the torque tool is accurately calibrated.

There are two types of torque tools: Type I (indicating), and Type II (impulse feel, click or setting type). Type I torque tools are equipped with a gage or indicator displaying the torque applied. Type II torque tools are set to 'break over' or create an impulse-click when a set point is reached.

The most widely used among the many varieties of Type II torque tools is the torque wrench, similar in appearance to a ratchet type socket wrench, and commonly adjustable to a range of set points in ft-lb (foot-pounds force) or Nm (Newton-Meters, the International Standard unit); although many are also set and sealed to a fixed, calibrated torque value.

This article will focus on Type II torque tools, as techniques for their calibrations are the most problematic; the main challenge being proper technique for accurately measuring the 'break over' set point. However, this article may also be useful in calibrations of Type I torque tools, as many of those techniques are common.

Preparation for the Calibration

Torque tools are either Clockwise only, Counter-Clockwise only, or usable in both directions. This is a small, but important detail which must be observed prior to beginning the calibration.

Assure that the torque calibrator has been warmed up for its prescribed time, and in all steps, take care that the range of the torque tool being calibrated and applied torque never exceeds the range of the calibrator.

The Calibration Process

Accurate calibration of torque tools is about technique. Understanding this and consistently applying good technique will go a long way in performing accurate torque calibrations. Following is an enhanced, generic procedure for Type II torque tool calibrations, including techniques to assure accurate results.

STEP 1: Relax the Spring

When an adjustable torque tool is received, adjust to its minimum marked set point (normally about 20% of range), to 'relax' its internal spring for at least 8 hours prior to the calibration. Do not try to adjust below its minimum marked set point, or the tool may become damaged. The tool temporarily remembers its spring's compressed shape, and will provide accurate results only after it has had time to 'relax' to its uncompressed shape. Also, allow 8 hours with the tool set to its marked minimum following out-of-tolerance adjustments, prior to proceeding with post-adjustment readings.

Note: Worn springs that do not fully return to their original shape, may require replacement. Fixed Value Type II torque tools, including wrenches, screwdrivers, T handle and others, which have been sealed and set for a fixed torque set point, do not require relaxing the spring prior to calibration, and should be left at the set point unless adjustments are needed.

STEP 2: Warm Up the Transducer

Before proceeding, or at least once each day, the calibrator transducer(s) to be used should be exercised ('pre-loaded') by applying at least three repetitions of torque at 100% of range for about thirty seconds each in the direction of calibrations that will be performed (Fig. 2). Allow the calibrator to rest for about thirty seconds between each application. Do not exceed the operating range of the calibrator.

Note: Some more recent model torque calibrators no longer require daily pre-loading. Refer to manufacturer's specifications on your calibrator for further information.

STEP 3: Warm up the Torque Tool

Exercising a torque tool lubricates and warms its mechanical components to simulate active use. Immediately prior to a calibration, set the torque tool to 100% of its marked range and exercise it in the direction to be calibrated a minimum of five repetitions. This may be done using a test fixture or the calibrator (provided its maximum range is not exceeded). Then reduce the set point to marked minimum in preparation for the calibration.

STEP 4: Set the Calibrator to 'First Peak' Mode

If the calibrator has a 'First Peak' mode, use it. This mode captures the first peak in torque during the break over at the set point, and disregards a second smaller peak which may occur afterward. If 'First Peak' mode is not available, set the calibrator for 'Peak' mode. With use of good technique, the second peak should be smaller and won't be recognized by the calibrator.

STEP 5: Position the Torque Tool in the Calibrator

Calibrator transducers are designed to be oriented either vertically, for the torque tool to rotate vertically (Fig. 4) or horizontally, for the torque tool to be rotated laterally (Fig. 5). Insert the torque tool either directly into the fitting on the transducer, or using a properly sized, snug-fitting adapter. When using a vertically oriented transducer, position the torque tool parallel with the floor and at a right angle to the transducer (Fig. 3), and oriented to be pushed straight down for the desired (clockwise or counter-clockwise) torque value. When using a horizontally oriented transducer, hold the torque tool so that it is at an exact right angle to the transducer, and clear from any obstructions.

Figure 2. Exercising the transducer.

Figure 3. Leveling the torque wrench.


Figure 4. Vertical orientation.

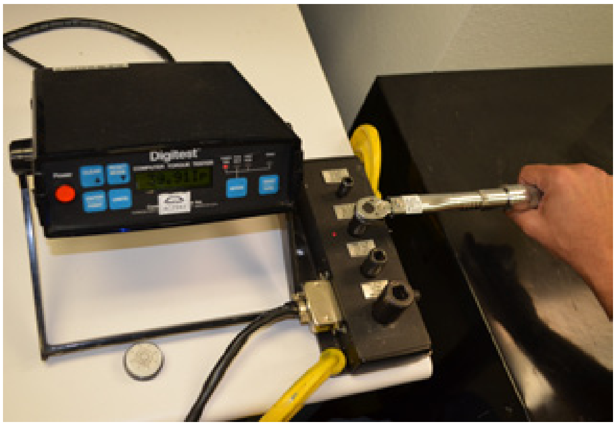


Figure 5. Horizontal orientation.

STEP 6: Make the Torque Measurement

Always begin calibration of a torque tool at its lowest marked set point. Then, dial up to each set point from a lower value. The normal recommended sequence is calibrating at marked scale increments nearest 20%, 60% and 100% of range (in that order).

Use a single range (transducer) on the calibrator when possible. For torque tools whose full range matches the full range of the calibrator, the check done at 100% of range on the torque tool should be performed at the scale increment nearest 90%. The torque tool is still considered fully calibrated using this method. This will avoid damage from over ranging the calibrator. If possible, the calibration should be performed on a single transducer of the calibrator, to reduce errors produced when switching between transducers.

Grip the torque tool properly. Position your hand at the center of the grip or on the stripe mark at the center of the grip on the torque tool. This is the calibrated point on the torque tool. Because torque is comprised of applied force times distance from the fulcrum (or axis), placement of the hand (where the force is applied) makes a difference in accuracy.

Use a Smooth Force. Accurate calibration of torque tools requires applying a smooth, gradually increasing, continuous force just until the set point is reached. Inconsistent application of force will result in inconsistent inaccurate readings. Apply a smooth, gradually increasing force to the torque tool until the break over point is reached.

Apply force at the right speed. If force is applied too rapidly, the torque tool will "bottom out" and produce inaccurate high readings. If it is applied too slowly, inherent friction in the torque tool will also produce an incorrect reading. Errors caused by inherent friction increase with lower torque set points.

Don't anticipate the break over. A common error among metrology technicians is to unconsciously slow down application of force as they anticipate the set point break over. This causes reduced, inaccurate readings. Do not anticipate the break over. Maintain smooth, continuous force until after the set point break over.

Apply force to the first peak. The set point is reached at the first peak, which occurs during the impulse at break over. Immediately after the first peak, reduce applied force.

Beware of the second peak. Following the first peak at the set point break over, as the tool 'bottoms out,' a second, smaller peak will occur. With proper technique (reducing applied force after the first peak), the second peak will be smaller, and will not cause a secondary reading on the calibrator. With the calibrator set to 'First Peak' mode, only the first peak will be recorded. In 'Peak' mode, only the first peak will read as long as the second peak is smaller.

Take five readings at each set point. Due to human variability, calibrator readings for each repetition will be a little different. Consistent and correct technique (which comes with practice) will reduce variability, but the calibrated torque value for a set point is considered to be the average of at least five repetitions. For this reason, most calibration procedures require taking the average of multiple readings (normally five).

Note 1: Be aware of muscle fatigue. This is may be more of an issue for higher set point torque tools, as they require more exertion. Be aware of muscle fatigue, as it will make applying repeatable, continuous force more difficult. When muscle fatigue is noticeable, take a break as needed.

Note 2: Use of a Loading Bench (Loader). A loading bench, 'loader' (Fig. 6), improves repeatability of the smooth, continuous force applied during calibration of Type II torque tools by removing much of the human variability, reducing muscle fatigue, and is very helpful in calibrating high torque values. The torque tool is normally mounted horizontally in the loading fixture, leveled vertically, and set to apply force at the center of the grip. The loader crank handle is then rotated at an even speed until the set point break over is reached. This method reduces many human errors but is more costly, and so is not available in many laboratories.

Torque Calibration Example

A Craftsman Micro-Clicker 10 to 75 ft.-lb. (CW & CCW) 3/8 inch drive torque wrench is received for calibration. When received, the TI (Test Instrument) is adjusted to its minimum marked setting of 10 ft.-lbs. and placed on an incoming hold shelf for 8 hours (overnight), while its internal spring is relaxed.

The following day, prior to beginning calibration on the TI, the calibrator transducer to be used is preloaded by exercising it three times in the direction to be calibrated (in this case, both directions) to 100% of range. The transducer used will be the 1000 in.-lb. (8.33 to 83.33 ft.-lb.) transducer, part of the CDI model TTPM-41 four transducer set.

The TI is then adjusted to its full range torque setting of 75 ft.-lbs. and exercised in the first direction to be calibrated (clockwise, for this example), exercised five times, then adjusted back to its minimum marked setting of 10 ft. lbs.

The calibrator is set for First Peak mode. Then, the TI is dialed to the first calibration setting of 15 ft.-lbs., inserted directly into the calibrator's 3/8 inch transducer fitting. The TI is held in a 'neutral' position while the calibrator is zeroed, if needed. Then, the TI is smoothly twisted clockwise, just until the break-over click is felt. The measured torque value is noted, and then the process is repeated four more times. All five repetitions must be within tolerance limits.

The TI is adjusted up to 45 ft.-lbs. (60% of range), and the measurement process is repeated.

The TI is adjusted up to 75 ft.-lbs. (100% of range), and the measurement process is repeated.

If all 5 calibrator readings at each set point are within tolerance, the TI is then adjusted back to its marked minimum setting. Positioning of the TI is switched to perform warm-up and calibration readings in the counter-clockwise direction.

The TI warm-up and all calibration steps are then repeated as above in the counter-clockwise direction.

Figure 6. Torque loader.

Once all readings have been taken in both directions, adjust the TI again to its minimum marked setting of 10 ft.-lbs. (where it should remain until it is to be used again) and complete calibration documentation.

Screwdrivers and T Handle Torque Tools

Most techniques in the procedure above also apply to screwdrivers and T handle torque tools. But screwdrivers and T handle tools rotate continuously, and have multiple break over points along their 360 degree rotation – which all must be calibrated. Below are additional techniques needed to accurately calibrate them.

Avoid Downward Pressure – Avoid downward force during the calibration process, as this will provide inaccurate results.

Straight Vertical Position – Keep the torque screwdriver or T handle tool exactly vertical to the torque transducer. Leaning the tool creates friction and will cause inaccurate readings.

Warm Up The Screwdriver – To lubricate and warm up internal components, rotate the torque tool 6 full rotations on a fixture or on the torque calibrator, provided the full range of the calibrator is not exceeded.

360 Degree Calibration – Using 'Peak' mode on the calibrator, slowly rotate the screwdriver or T handle a full 360 degrees with a smooth, continuous force, pausing after each break over to allow the peak indication on the calibrator to reset. Note the actual torque at each break over, and be sure every break over during the entire rotation is within allowed tolerance.

Technical References

[1] *EURAMET*/cg-14/v.01 July 2007, "Guidelines on the Calibration of Static Torque Measuring Devices."

[2] *INTERNATIONAL STANDARD ISO6789* Third Edition 2003-04-01, "Assembly tools for screws and nuts – Hand torque tools – Requirements and test methods for design conformance testing, quality conformance testing and recalibration procedure."

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Wide Band Microwave Noise Measurement System

Murat Celep
TÜBİTAK Ulusal Metroloji Enstitütüsü

In the wide band radiometer, it is necessary to use more than one low noise amplifier (LNA) because of their narrow band characteristic. The change in the gain of the LNAs with different frequency ranges was kept at minimum value by continuously terminating the LNAs' ports with a load whose impedance is equal to impedance of match load. Thus, in order to perform the noise measurements of solid state microwave noise sources between 50 MHz and 26.5 GHz frequency range at a time, a wide band radiometer was established. The calculated ENR uncertainties for measurements done by the radiometer are lower than 0.34 dB (k=2).

I. Introduction

The radiometers used in microwave noise measurements are composed of four major parts that are the switching section, RF section, IF section and detector section [1]. The switching section is used for selection of noise source to be connected to the radiometer input whereas the RF and IF sections are used to amplify the microwave noise applied to the radiometer input and to filter and amplify the noise signal with high frequency by down converting it to a lower frequency, respectively. The detector section, on the other hand, is used to measure the amplitude of noise signal down converted to intermediate frequencies (IF). Although the switching section, IF section and detector section can readily be established for measuring wide band noise signal, it is not the case for the RF section. Since the microwave elements in the RF section, such as a low-noise amplifier (LNA), isolator and mixer, cannot be manufactured as wide band elements, the frequency of this section is limited by the frequencies of the microwave elements. For this reason, the radiometer systems are designed to operate only at one frequency band [2]. Yet, solid state noise sources used in metrology are wide band devices [3]. Therefore, to measure a wide band noise source, more than one narrow band radiometers are needed and this is both laborious and time consuming.

In this article, design, production and automation of a total power radiometer operating in wide band range to measure microwave noise generated by noise source are reported. With the system described in this work, the excess noise ratio (ENR) value of a noise source operating between 50 MHz and 26.5 GHz can be measured. In order to reduce the measurement errors due to the operator, software was also developed.

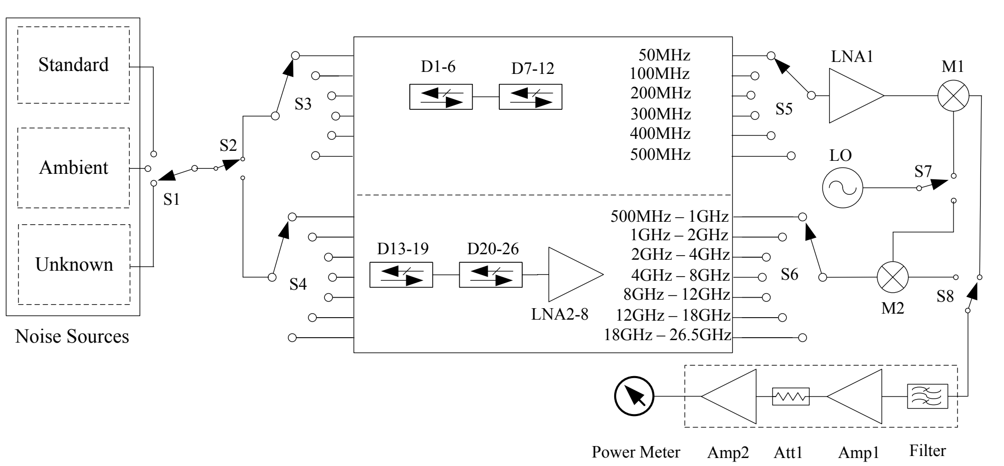

Figure 1. Wide band total power radiometer.

II. Wide Band Radiometer

In metrology institutes, there are two types of radiometer used in calibration of noise sources. These are Dicke radiometer [1, 4] and total power radiometer [5]. At UME, National Metrology Institute of Turkey, to perform a microwave noise measurement, a total power radiometer with good sensitivity and drift performance was preferred. In order to perform the wide band ENR measurements, all frequency points must be swept without break. It is very difficult to establish a radiometer operating between 50 MHz and 26.5 GHz due to the use of a low-noise amplifier (LNA), isolator and mixer in the system, because isolators and LNAs operate in narrow band. In order to operate the radiometer in wide band, it is necessary to have isolators, LNAs and mixers cover all frequency bands between 50 MHz to 26.5 GHz. The way of making these elements with different frequency ranges operate together in the same system is to bring them together with a switching system. Bringing the microwave elements operating at different frequency ranges together by a switching system, a total power radiometer operating between 50 MHz and 26.5 GHz has been developed at UME. The block diagram of this radiometer is given in Fig. 1 [6].

There are five channels at 50 MHz, 100 MHz, 200 MHz, 300 MHz, 400 MHz and 500 MHz frequency points and 500 MHz - 1 GHz, 1 GHz - 2 GHz, 2 GHz - 4 GHz, 4 GHz - 8 GHz, 8 GHz - 12 GHz, 12 GHz - 18 GHz and 18 GHz – 26.5 GHz frequency bands in the radiometer. According to the measurement frequency, a channel is selected. Switches S1, S2 and S3 or S1, S2 and S4 are positioned to apply output of the noise source to the selected channel input. The noise signal coming to the channel input compatible with a selected frequency is applied to the amplifier after passing through the isolators and then is applied to mixer. Positioning switch S7, local oscillator (LO) output is applied to the input of the mixer compatible with the frequency. The noise signal down converted to an IF at the output of the mixer passes through the amplifiers and filter after being selected by switch S8. After being filtered, the signal is read on the power meter.

In the case of change of the frequency band, the load impedance of the newly selected channel alters from open circuit to characteristic impedance. On the contrary, impedances of the previous channel used alter from characteristic impedance to open circuit. However, the design of a LNA is made by the criteria that necessitates the input impedance (Z_i) and the output impedance (Z_o) being equal to complex conjugate of source impedance (Z_g) and load impedance (Z_l) given in the Fig. 2. In other words, the equations $Z_i = Z_g^*$ and $Z_o = Z_l^*$ must be satisfied. Unfortunately, the load impedances at the output of the LNAs, seen in Fig. 1, continuously vary when used above 500 MHz. The output of the LNA that is used at channel is terminated with loads equal to characteristic impedance.

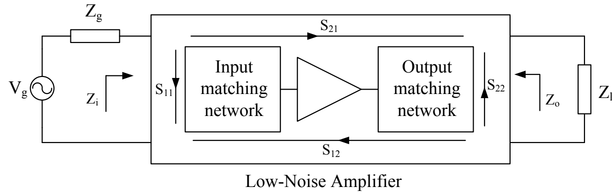

Figure 2. Input and output connections of a LNA.

When the LNA is not used, its load impedance value is changed as infinite.

In terms of s-parameters, the gain of a LNA in the LNA model circuit given in Fig. 2 is written as

$$G_T = \frac{(1 - |\Gamma_g|^2)\,|S_{21}|^2\,(1 - |\Gamma_l|^2)}{\left|(1 - S_{11}\Gamma_g)(1 - S_{22}\Gamma_l) - S_{12}S_{21}\Gamma_g\Gamma_l\right|^2}, \quad (1)$$

where Γ_g, S_{21}, Γ_l, S_{11}, S_{22} and S_{12} are the source reflection coefficient, the forward transmission coefficient of the LNA, the load reflection coefficient, the input reflection coefficient of the LNA, the output reflection coefficient of the LNA and the reverse transmission coefficient of the LNA, respectively.

In the case of variability in source and load impedance, the gain of LNA is obtained as in Fig. 3 using Eq.(1).

While the highest LNA gain is at the point where the source and the load impedances are equal to characteristic impedance, it appears that the gain declines when diverging from characteristic impedance.

The measurement setup in Fig. 4 was established to verify the theoretical results. After the impedance values were specified at 20 GHz according to different positions of the MMT-2604 model tuner connected directly between the VNA ports, the Miteq-AFS33 model LNA was introduced as shown in Fig. 4. Then, LNA gains were measured by changing the load impedance of LNA with different tuner positions.

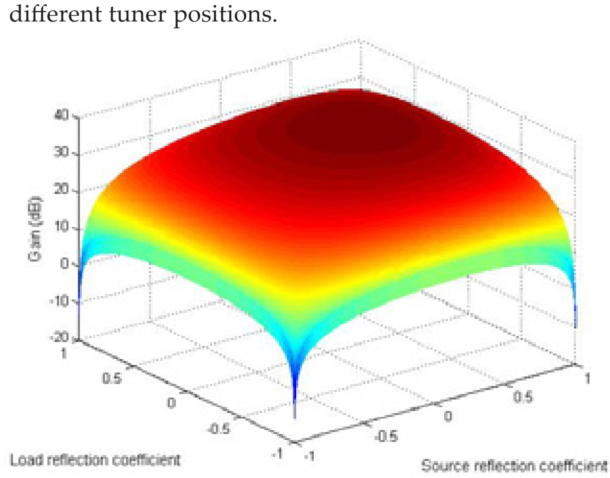

Figure 3. Variation in LNA gain.

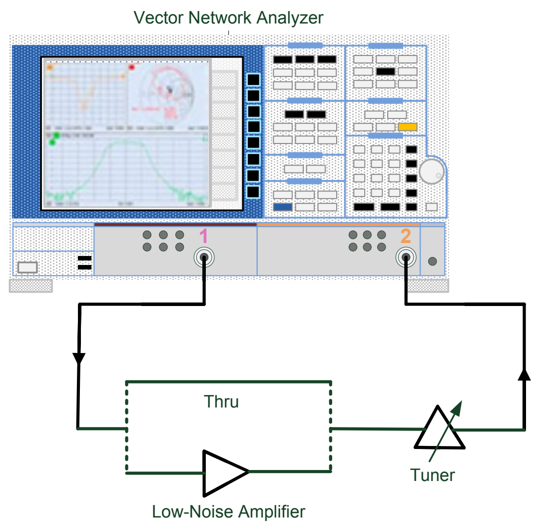

Figure 4. Measurement setup for LNA gain due to change of load impedance.

Moreover, the LNA gain values at 20 GHz were calculated using LNA s-parameters, source and load impedance reflection coefficients. The gain values directly measured by the VNA and those calculated by Eq.(1), seen in Fig. 5, are found to be compatible with each other.

The curves in Fig. 5 involve only the case that $|\Gamma_g|$ has constant value and that $|\Gamma_1|$ changes between 0 and 0.8, which is some partition of the graph in Fig. 3. The change in the gain, when $|\Gamma_1|$ changes between 0 and 0.8, is higher than 10 dB for both theoretical and experimental results shown in Fig. 5.

Variable port impedance, as well as the LNA gain, changes the noise figure value produced by LNA [7]. This increases the waiting time needed for equilibrium of LNA after each impedance change. A long waiting time between two measurements leads to both changes in the radiometer gain and increases in the measurement time due to the large number of measurements. Prolonged measurement time for such a system is not acceptable [8].

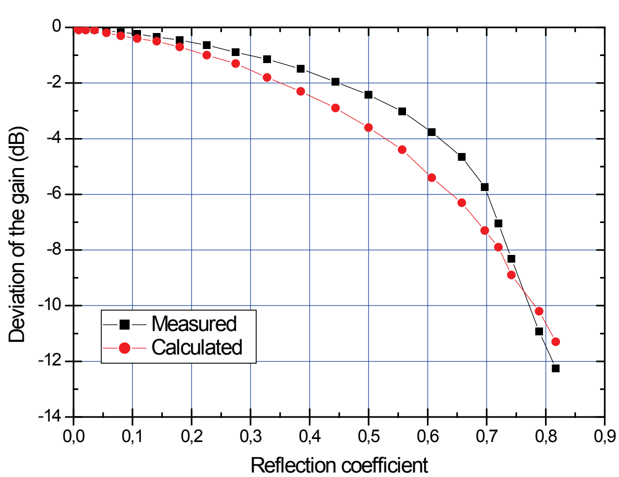

Figure 5. Deviation of the LNA gain versus load reflection coefficient [6].

Moreover, variable LNA gain negatively affects both radiometer gain and radiometer sensitivity [1]. Therefore, whether currently in use or not, load impedance of the LNA in the channel should be approximately equal to the characteristic impedance. However, it is not possible for a standard switching system. A Dow-Key 571K model microwave switch with the structure given in Fig. 6 was used to keep the LNA load reflection coefficient value close to zero when the LNA is out of use. In this case, LNA output is connected to match load.

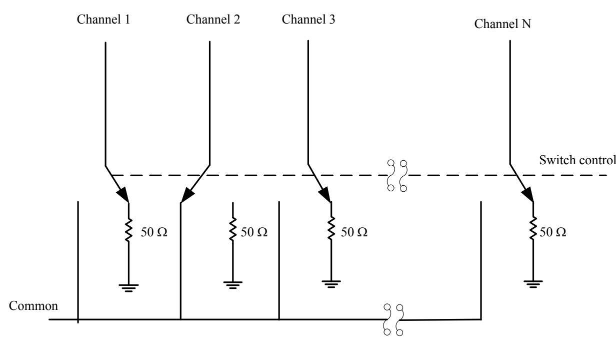

Figure 6. Loaded microwave switch.

The microwave elements that are currently out of use but connected to the switch are terminated with a 50 Ohm load by using the loaded microwave switch. Thus, holding the working conditions similar, the LNAs have been made to have stable gain.

III. Measurement Procedure

For noise source and measurement channel selection to use in the system, and for data acquisition, software was developed. Using Microsoft® Visual Basic®, an interface was built up whose flow diagram is given in Fig. 7.

In the interface, there are the inputs to enter certain information such as measurement frequencies, power values applied by a local oscillator, operator, environmental conditions and remarks for noise sources used. The software uses measurement frequencies and LO power values as input. It is necessary to select the LO output power values correctly in order to make a mixer operate efficiently. Thus, the entry of power value of LO was left to the operator.

At the beginning of the measurement, the standard noise source channel is selected by a S1 switch. Then, in order to select the channel compatible with the measurement frequency, S2 - S8 switches are used.

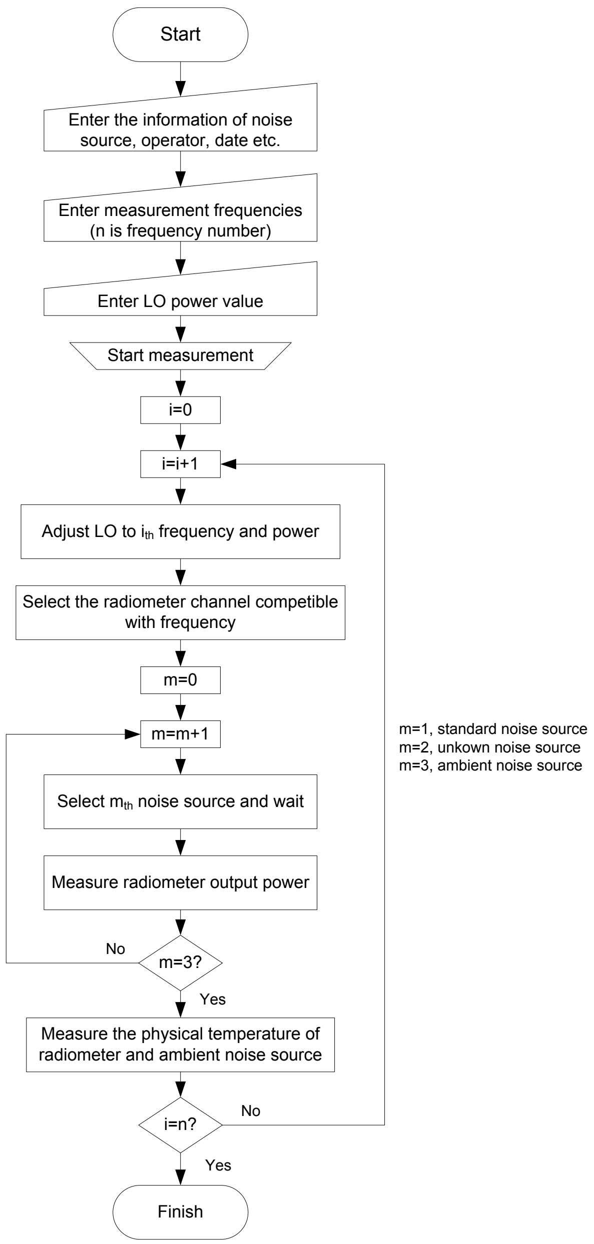

Figure 7. Measurement software flow diagram.

After adjusting the LO to the frequency needed for maintaining IF frequency at the output of mixer, the system is left for stabilization. When the power read from the display of the power meter becomes stable, data is taken. Afterwards, the same procedure is repeated for unknown noise source and ambient noise source in turn at the same frequency. In order to measure the physical temperature of the load used as ambient noise source, a resistor with negative temperature coefficient (NTC) is used. Similarly, radiometer temperature is measured with another NTC. An entire measurement for one frequency takes approximately three minutes. The measurement steps are then repeated for the remaining frequencies. The measurement cycle finishes after the last frequency.

IV. Measurement Results

Microwave noise measurements between 50 MHz and 26.5 GHz were performed by wide band radiometer. In these measurements, two NC346C model noise sources with 15 dB ENR certified by National Physical Laboratory of United Kingdom (NPL) were used. One of the noise sources was used as the standard and the other as unknown. Substitution of the measurement results and the radiometer parameters to Eq.(2) leads to calculation of noise temperature of the unknown noise source [9]

$$T_x = T_a + (T_s - T_a)\frac{(Y_x - 1)\, M_s\, \eta_s}{(Y_s - 1)\, M_x\, \eta_x}, \qquad (2)$$

where T_a is the ambient noise temperature (K), T_s is the standard noise temperature (K), Y_x is the ratio of output powers (unknown Y-factor) when unknown and ambient noise sources are alternately connected to the radiometer input, Y_s is the ratio of output powers (standard Y-factor) when standard and ambient noise sources are alternately connected to the radiometer input, M_x is the mismatch factor between the unknown noise source and the radiometer input, M_s is the mismatch factor between the standard noise source and the radiometer input, and η_x and η_s are the efficiencies of microwave switch paths connected to the unknown and standard noise sources.

ENR values were calculated with the help of the equation ENR (dB) = $10\log((T_x - T_0)/T_0)$, after noise temperature of T_x had been calculated. Calculated and certified ENR values of the unknown noise source are given in Fig. 8.

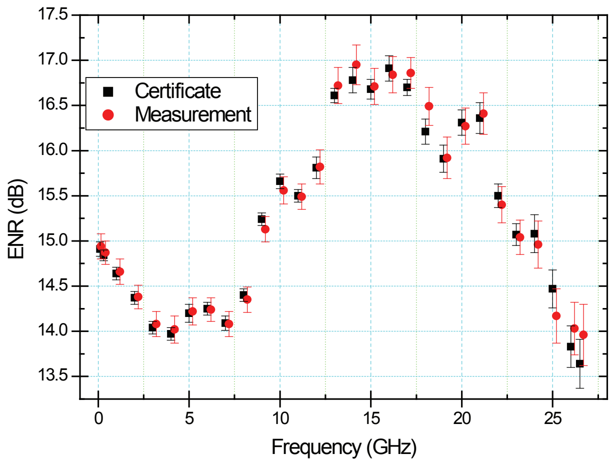

Figure 8. ENR measurement result [6].

The measurements give uncertainties between 0.13 and 0.34 dB. The difference between ENR values calculated and those given in the certificate vary from −0.32 to 0.30 dB that falls into acceptable range of the measurements.

Conclusions

A wide band radiometer for microwave noise measurement has been designed, established and automated to operate between 50 MHz and 26.5 GHz. In order to utilize the radiometer in wide band frequencies, LNAs outputs are terminated with match load when they are not in use. Using two noise sources, radiometer was tested and the results obtained for an unknown are in good agreement with the actual ENR values of the unknown noise source.

Acknowledgment

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Power Sensor Calibration Software

PS-Cal is the first truly Windows® Based power sensor calibration solution capable of testing multiple sensors at one time. It is by far the easiest to use, most customizable and state-of-the-art solution on the market. PS-Cal software is designed to perform all of the required tests on power sensors including rho, cal factor and linearity. Currently, it is the only third-party solution capable of completely testing the Agilent E-Series power sensors.

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- ☑ Customizable
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- ☑ State-of-the-Art
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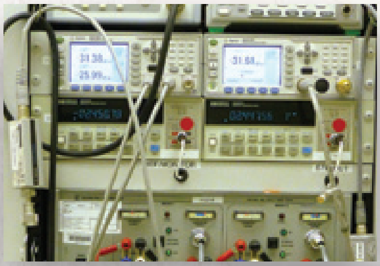
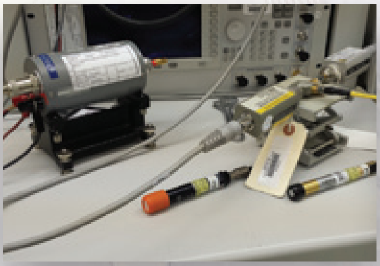
- ☑ Threaded Application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Accelerate TDR Measurements with Electronic Calibration

John Dorighi and Rob Sleigh
Keysight Technologies Inc.,
formerly Agilent Technologies electronic measurement business

An important consideration for improving the accuracy of time domain reflectometer (TDR) measurements is user calibration. A TDR user calibration is performed to correct for systematic instrument errors along with removing losses and reflections from cables, fixtures, and adapters. The measured system response is compared to the known response of a standard to determine the appropriate correction. Calibration ensures the most accurate measurements of a device under test (DUT). Traditionally, TDR calibration is performed by connecting a mechanical short and load at the measurement reference plane. Calibration using mechanical standards can be time consuming and error prone as channel count increases. Electronic calibration, or E-Cal, is a solution to this problem. Electronic calibration was pioneered for Vector Network Analyzers (VNA) and has been in use for more than a decade to make calibration faster and simpler. E-Cal takes advantage of a single connection to the calibration module which contains various impedance states that can be automatically switched into the measurement path. This article will focus on the application of electronic calibration for TDR/TDT.

A traditional signal integrity tool for characterizing electrical transmission lines is the time domain reflectometer or TDR. This is an instrument which launches a voltage step and measures the reflected signal or transmitted signal.[1] The reflected signal provides information such as impedance vs. distance, the location of discontinuities, and the round trip propagation time. The transmitted step measured at the end of a device yields the step response, the one way propagation time, and also skew between channels. This is known as a time domain transmission, or TDT, measurement. The time domain results can be converted into the frequency domain to provide the S-Parameters, return loss or insertion loss, of a device. S-Parameters from a TDR/TDT based measurement correlate well with measurements performed by a vector network analyzer, VNA, which is the gold standard for S-parameter measurements, although there are measurement trade-offs between the two instruments.[2]

An important consideration for both TDR and VNA measurements is the user calibration which removes systematic instrument errors and corrects for cable, fixture, adapter loss and reflections. A traditional approach to perform a user calibration is measuring the electrical characteristics of a mechanical standard, such as a short, open or a load. The measurement location of a standard defines the reference plane where the device under test is connected. Comparing the measured response at a reference plane to the known electrical characteristics for each of the standards corrects for the unknown response of fixtures and cables. This isolates the measurement to the device providing a more accurate result.

For a 2 port single ended device, such as a coaxial cable, the calibration procedure using mechanical standards is straight forward. However, modern communication standards require 4 to 10 lanes to achieve ultra-high speed links. As the device port count increases, manually performing the calibration using mechanical standards quickly becomes unmanageable. Electronic calibration, or E-Cal, is a solution to this problem. E-Cal takes advantage of a single connection to a module which contains various impedance states that can be automatically switched into the measurement path. A typical electronic calibration module is shown in Figure 1. This article will focus on the application of electronic calibration for TDR/TDT measurements to make high channel count measurements faster and much easier.

Figure 1. Electronic Calibration (E-Cal) Module.

Importance of TDR/TDT Calibration

It is possible and often practical to perform TDR/TDT measurements before performing a user calibration. Simply connecting the TDR sampling head to a device allows the user to quickly isolate the distance to a discontinuity, investigate the location of reflections, and measure propagation time in a transmission line. However, for the most accurate measurements of a device under test, a TDR/TDT user calibration is recommended. Sources of measurement uncertainty can include instrument imperfections such as stimulus edge speed, step flatness, channel bandwidth, and the sampler frequency response. For example, overshoot and ringing in the incident step can mask device reflections making it difficult to isolate if an imperfection is due to the incident step or the device under test. The TDT step response before and after calibration is shown in Figure 2 where the calibrated step removes imperfections and provides a better stimulus for a more accurate measurement of the device under test.[3]

There are additional imperfections external to the instrument which can create measurement uncertainty. These include losses and reflections from cables, adapters, and test fixtures which degrade the incident step arriving at the reference plane. Ideally, the TDR sampling head can be positioned close to a device under test minimizing these errors, a remote TDR head helps meet this requirement. If test fixturing is present, a TDR calibration will shift the measurement reference plane closer to the device and remove reflections and losses before the launch into the device.[3]

Another benefit of TDR/TDT calibration is the effective edge speed of the stimulus can be changed after calibration. Figure 3 shows a pair of closely spaced discontinuities measured with a range of edge speeds. A TDR measurement with a faster edge speed is able to resolve more closely spaced discontinuities.[4] Performing a TDR calibration corrects for test system imperfections, test fixturing before the device, and allows the user to vary the TDR edge speed. A TDR calibration insures the most accurate measurements of a device.

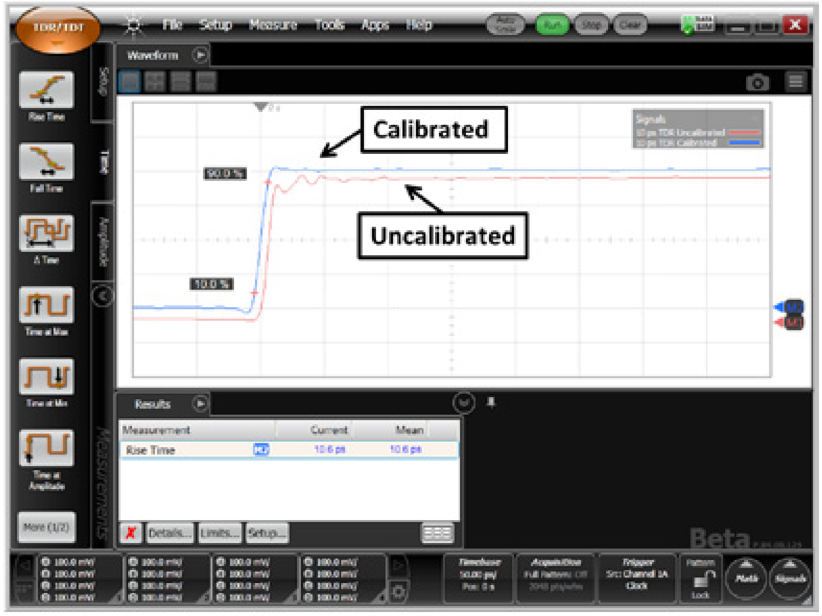

Figure 2. TDR Step Response before and after calibration.

Figure 3. A pair of discontinuities on a test board measured using different edge speeds.

Electronic TDR Calibration - A New Approach

A new approach to perform a TDR calibration uses an electronic calibration or E-Cal module. Electronic calibration was pioneered for Vector Network Analyzers (VNA) to make calibration faster and easier and has been in use for more than a decade. Benefits of the electronic calibration include: less chance of operator error, fewer connections, faster calibration time, and less connector wear and tear. An E-Cal module is a transfer standard rather than an absolute standard. Each E-Cal module might have a slightly different electrical response for each standard, but calibration data unique to each standard is measured and stored as part of the manufacturing process. This ensures the transfer standard used for each measurement is traceable to the National Institute of Standards and

Figure 4. TDR/TDT E-Cal Module with TDR sampling heads connected.

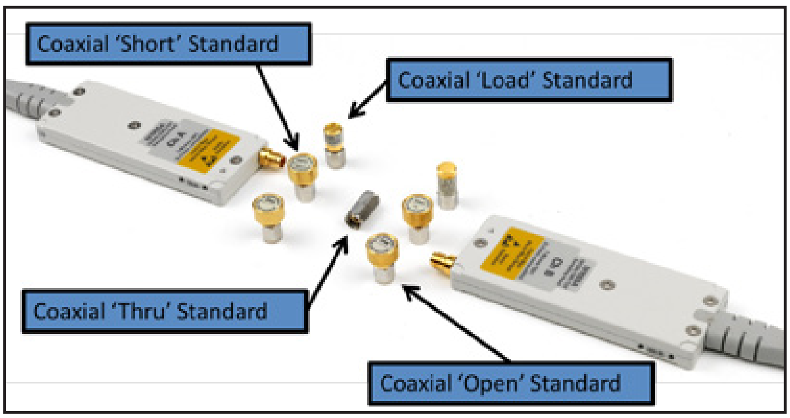

Figure 5. Mechanical Standards required for a 2 port calibration.

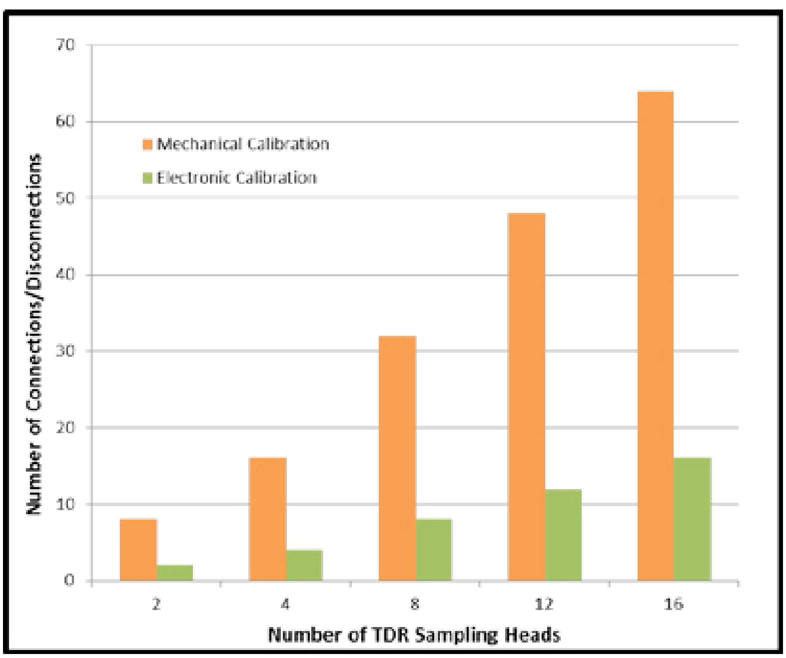

Figure 6. Required Number of Connections for Calibration vs. TDR Head Count.

Technology (NIST).[5] There are 7 unique electronic states measured during the E-Cal, each new state is switched into the measurement path automatically using a FET switch. Other than a connection to the E-Cal module, no user intervention is required during the calibration. There is one important difference between a VNA and TDR E-Cal module. Recall a TDR can perform measurements to DC while a VNA has a low frequency limit, often in the 10's of MHz. A TDR E-Cal module is designed to ensure standards are characterized to DC. As a result, a standard VNA E-Cal module cannot be used for TDR electronic calibration.

To perform an electronic calibration each TDR sampling head only needs to be connected to the E-Cal module one time. A photo of a 2 port E-Cal is shown in Figure 4 where only two connections are required. A mechanical calibration for a similar number of ports requires 8 connections as shown in Figure 5.

The total connections/disconnections for both mechanical calibration and electronic calibration vs. TDR head count is summarized in Figure 6. Clearly, the number of connections/disconnections is reduced using an E-Cal module in place of mechanical standards.

The time required to connect/disconnect standards during calibration is a significant portion of the total calibration time. This is shown in Figure 7 which plots the total time for a mechanical calibration and electronic calibration vs. the number of TDR sampling heads. In general, the electronic calibration takes about half the time as a mechanical calibration to complete. One point here is that additional impedance states are measured for each port during an electronic calibration, so the E-Cal measurement time for a given port count is longer. Ultimately, there is an overall time savings using an E-Cal module due to the fewer number of connections. Additionally, user intervention is significantly reduced during an electronic calibration.

Multilane Device Measurement Example

Once calibration is complete, a device can be connected and measured. The number of signal paths which need to be measured depends on the number of device ports. For a 2 port device a total of 4 measurements are required. As device port increases, the required number of measurements scales as the square of the device port count. For example, a 4 port device requires 16 measurements, an 8 port device requires 64 measurements, and a 16 port device requires 256 measurements.

A multilane device traditionally characterized using TDR is an InfiniBand® passive electrical cable which supports 4 lanes of traffic at 10 Gbit/sec.[6] InfiniBand® is a high speed, bidirectional point to point communication link which uses multiple lanes to increase throughput. Similar to a single lane device, it is important to characterize the TDR/TDT for each lane of a multilane device. In addition, the impact of adjacent aggressor lanes on a victim channel needs to be investigated. This is important as signal cross talk between lanes can degrade eye opening and potentially cause bit errors at the receiver.

The test connections using 8 TDR sampling heads are shown in Figure 8. The step simulating port 1 is measured at each of the 4 ports. The time domain reflected signal, TDR, is measured at port 1 while the transmitted step, TDT, is measured at port 2. The near end cross talk signal, NEXT, and far end cross talk signal, FEXT, are respectively measured at ports 3 and 4.

The test setup to measure the cable is shown in Figure 9 where a test fixture at each end of the cable adapts the coaxial launch of the test equipment to the connector at the input/output of the cable. Unused ports of the test fixture need to be terminated with 50 Ohms. The

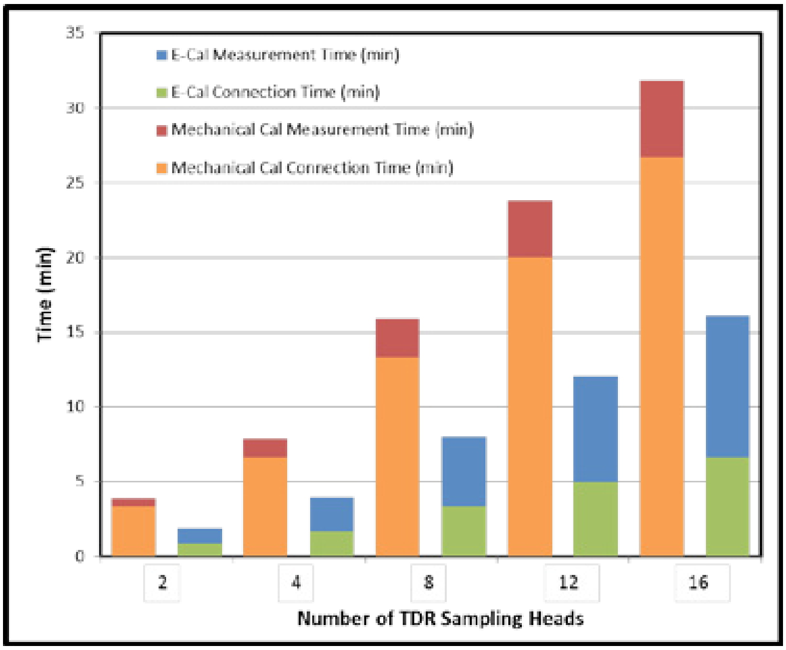

Figure 7. TDR/TDT Calibration time vs. the number of TDR remote sampling heads.

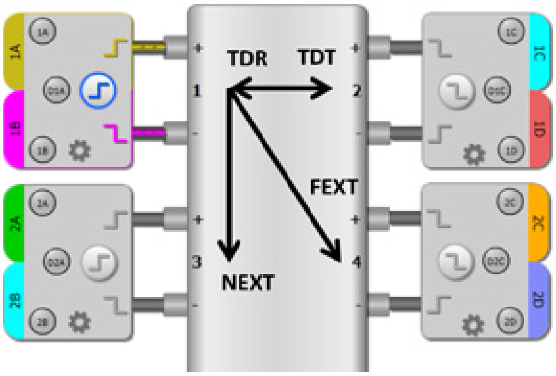

Figure 8. Test Connections Required for TDR, TDT, NEXT, and FEXT.

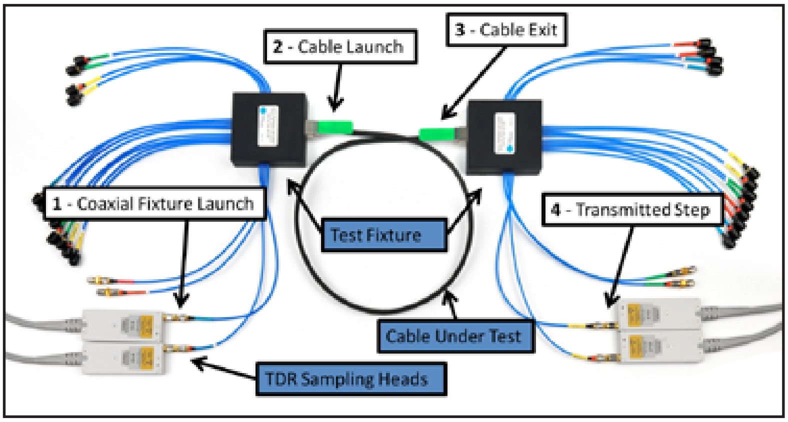

Figure 9. Test setup to measure a passive 4 lane cable assembly.

time domain measurement results for a 10 ps edge speed are shown in Figure 10. One point is that the vertical units and scaling for each waveform are different. The vertical unit for the TDR waveform is Ohms, while the other waveform units are in mV. The cross talk scaling for NEXT and FEXT, 2 mV/div, is significantly smaller than the TDT incident step scaling, 100 mV/div. The TDR plot shows the reflections from the coaxial launch into the fixture, also clear are the reflections at each end of the cable under test. Comparing the TDR reflections to those in the NEXT plot demonstrates that the coupling onto the victim lane occurs at each end of the cable. A similar conclusion is reached comparing the TDT waveform to the FEXT waveform.

The time domain results can also be displayed in the frequency domain as S-parameters. Useful insight into the device performance can also be extracted from the S-parameter results. The return loss and insertion loss, SDD11 and SDD21, for the cable is shown in Figure 11. Also shown for comparison are the S-Parameters measured by a Vector Network Analyzer—close agreement between the two measurement instruments is shown.

In practice, the minimum number of sampling heads required to perform a differential TDR measurement is 2, while a differential TDR/TDT measurement requires 4 sampling heads. There is a measurement time trade-off between the number of TDR heads available to measure a given number of device ports. This is demonstrated in Figure 12 which shows the number of connections and disconnections required to fully characterize a 16 port device based on TDR head count. Regardless of the number of TDR sampling heads, each of the unused ports should be terminated with a 50 Ohm load. Additional TDR sampling heads helps reduce test time when characterizing multilane devices and Electronic calibration, or E-Cal, is the most efficient method to calibrate multiple TDR sampling heads.

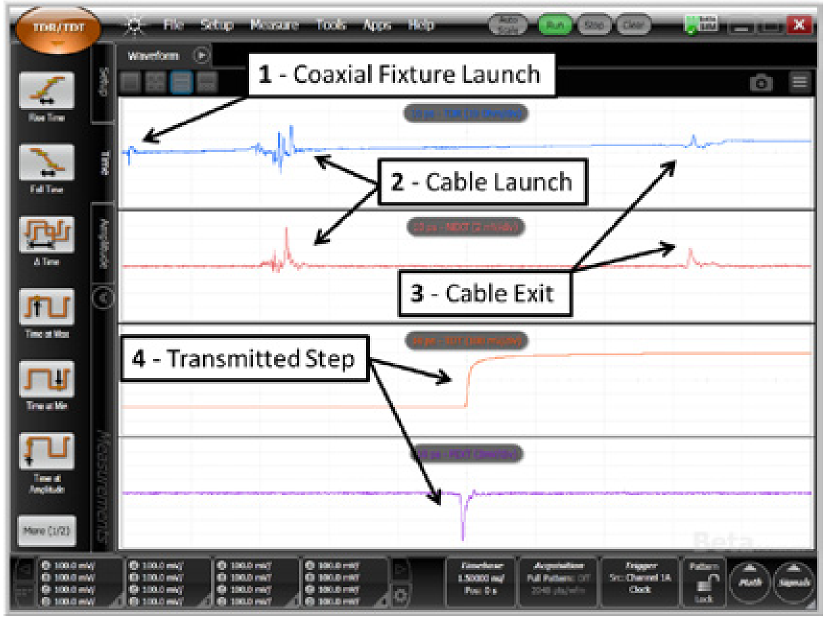

Figure 10. TDR, NEXT, TDT, and FEXT Measurement Results.

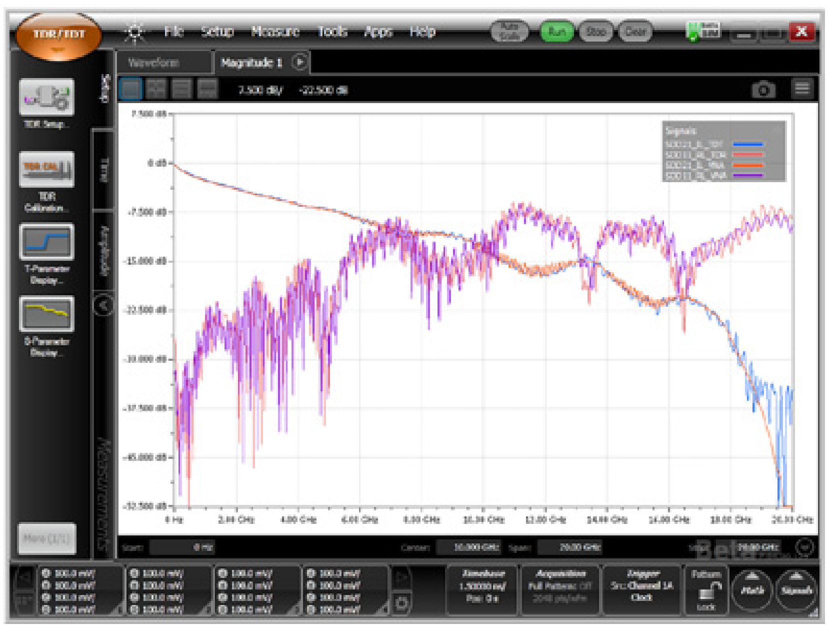

Figure 11. Insertion Loss, SDD21, and Return Loss, SDD11, measured using TDR and VNA.

Conclusion

TDR calibration ensures the most accurate measurements by removing systematic instrument errors and correcting for fixturing losses and reflections. Traditional TDR calibration using mechanical standards becomes tedious and time consuming as the device port count increases. A new approach using

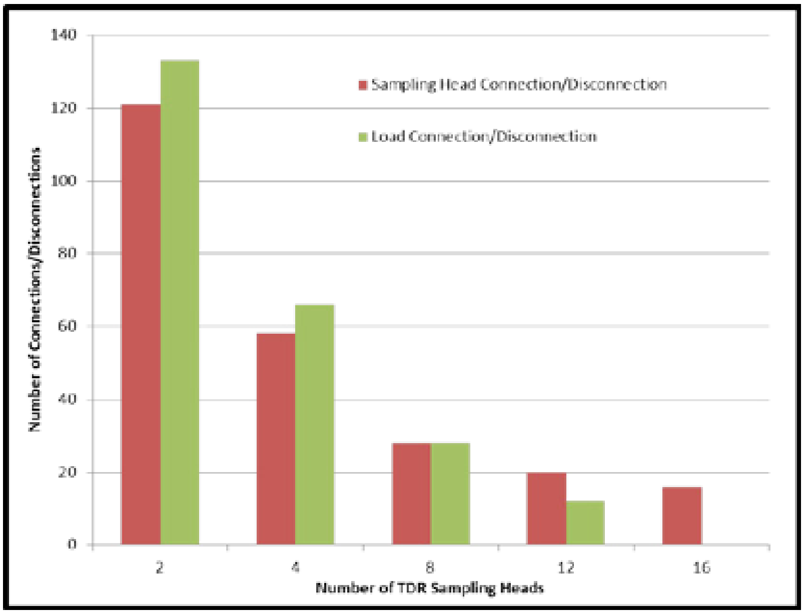

Figure 12. Connections / Disconnections required for a 16 port device based on number of TDR sampling heads.

an electronic calibration module, or E-Cal, significantly reduces the number of connections which reduces the overall time required to measure a modern multilane device.

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Calibrating a UUT on a Remote Computer Using Fluke MET/CAL®

Michael L. Schwartz
Cal Lab Solutions, Inc.

Current and next generation test equipment will be modular and tightly coupled with a computer's operating system. Calibration labs have to be highly dynamic supporting all the measurement test systems turned in for calibration. This presents challenges for automation, but technologies can be designed to work together. This paper will show how a Fluke MET/CAL® procedure can be written integrating Metrology.NET® tools to remotely calibrate a UUT connected to a remote computer on a completely different operating system. To do so, we will first cover the basic design patterns of remote computing, show how we create the command interface for a non-message based instrument, then how to remotely communicate with the instrument.

The Problem

PXI & PXIE instruments are growing in popularity, so calibration labs are working to find solutions to support them internally. Many manufacturers have created support solutions to help self-maintainers, but not all calibration labs are able to retool to support the software. High accuracy standards are very expensive; so many calibration labs are looking to support more equipment with a smaller footprint of hardware.

In this example, one of our customers was looking for a custom solution to support National Instruments PXI 5122. They have and use the Calibration Executive from National Instruments, but do not support enough oscilloscopes to justify the purchase of a Fluke 9500. Instead, their lab has a Fluke 5520—a standard fully capable of calibrating the PXI 5122.

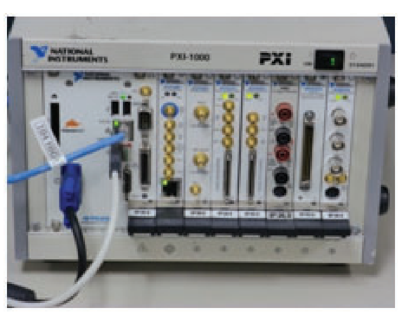
Looking at the Problem in the Problem Domain

- The calibration lab needs a way to support the PXI-5122 in house
- They do not have a Fluke 9500
- They have a Fluke 5520
- Testing them manually is not an option

Our Approach

Fluke MET/CAL® is a very popular software tool used by many calibration labs around the world. For our problem with testing PXI instruments, utilizing MET/CAL® seemed a good starting point. But controlling instruments like PXI and other modular and software based instrumentation presents itself with a level of complexity.

Having recently developed procedures for two other PXI instruments from another manufacturer, we learned software based instruments do not always run on every operating system. We needed to create a software development model that would contain complexity of the software in an easy to understand programming interface, while at the same time, minimizing operator frustrations related to configuration and operation of the calibration procedure.



We know the life expectancy of most hardware is ten to fifteen years, while software is only five years, so we know we have to expect the software platforms around the hardware will change two to three times over the life of the hardware. We also know that not all systems and customers would upgrade software at the same time; ultimately, we needed to decouple the UUT code from the standards code.

Overview of Our Solution

Working with our customer, we decided to divide the software up into two sections: the UUT code and the standard's code. We have decoupled the UUT code from the standard's code before, but this time we wanted our solution to be able to run cross computer. This would allow the UUT portion of the code to run on a completely different computer and operating system. It would also allow the UUT to be tested in the PXI chassis without the need for the technician to install MET/CAL® on the PXI Controller.

To accomplish this first we had to create a text command interface for the UUT, allowing MET/CAL® to control the UUT using commands similar to how we would control equipment on the GPIB bus. Then we needed to create a service to run on the UUT PXI chassis that would translate the commands to instrument function calls. It would be able to read the message, configure the instrument making measurements, and return the results.

Once the UUT Service was completed, we then needed to create a client messaging application because MET/CAL® at present does not have any direct access to TCP/IP based message calls. This was the simplest part of all the code, mostly because we already had tools developed to facilitate integration with MET/CAL®.

Once all the tools were developed, all we had left to do was to write the actual MET/CAL® procedure and then test it, in order to make sure the software was able to run distributed across two computers or all on the same computer.

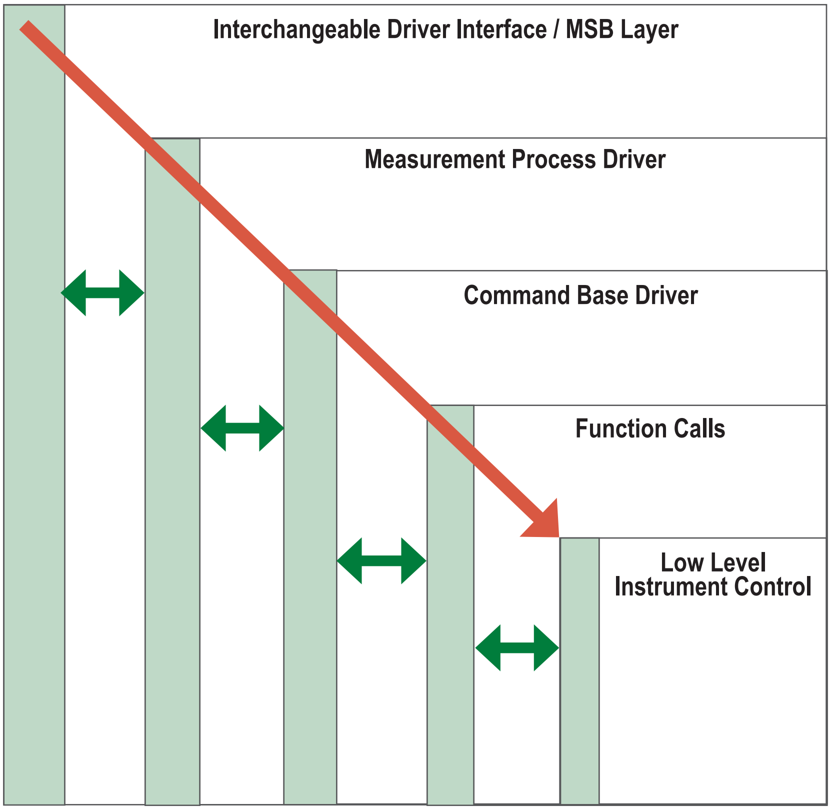


Figure 1.

Cal Lab Solutions Software Layers

We start to see patterns over time as we build software. Different companies and different people will name and label objects and layers in their software differently. But when we step back, the patterns are often the same. As software developers, we have to recognize these patterns and use them to simplify our software designs.

At our highest level of software abstraction is our Metrology Service Bus Layer (see Figure 1). This layer is designed to be language agnostic and platform independent. It creates a common interchangeable layer for driver interchangeability. Below that is the Measurement Process Driver. These can be created in any language and their main focus is measurement quality.

I should point out that not all instruments are command based; some measurement drivers can communicate directly with the function call and low level instrument control. But the overall goal of this development model is to create more flexibility in software design, so we can include it as part of our standard development methodology.

The command base driver is essentially the IEEE SCPI calls and RS-232 programming we normally use to send commands to an instrument. The firmware in the instrument will recognize our string based commands and call the corresponding function that performs that operation. For example, when sending it a "*RST" command, the firmware would call an internal Reset() function placing the instrument in a known state. The Reset() function would call all the low level peaks and pokes to set up the hardware.

Creating a Command Set

Most instruments are controlled using a command based language, but we are seeing more and more of the newer software based instruments do not support a command based language. Instead, they expose function calls that are accessed directly from our software. This direct exposure to the function calls allows for faster execution and better performance, but then creates issues for the calibration lab because much of our software has been built for command based instruments.

To communicate with a software-based instrument using a message based command language requires a command processer. Writing a command process that will convert the simple text based commands to function calls can be a very simple process. First you have to define the command language then write a string parser to process each command. One simple solution is to create a giant case select that acts on each command. As the command processer receives each command, it

Command	Function Call
IDN:	
Reset:	niScope_init
SelfCal:	
SelfTest:	
ConfigureChanCharacteristics: Channel= ,Impedance= ,Bandwidth=	niScope_ConfigureChanCharacteristics
ConfigureVertical: Channel= ,Coupling= ,Attenuation= ,Range= ,Offset=	niScope_ConfigureVertical
ConfigureHorizontalTiming: SampleRate= ,Position= ,Points=	niScope_ConfigureHorizontalTiming
ConfigureEdgeTrigger: Channel= ,Slope= ,Coupling= ,Level=	niScope_ConfigureTrigger
ConfigureImmediateTrigger:	niScope_Initiate
Commit:	niScope_Commit
Measure: Channel= ,NumberOfAverages= ,Measurement=	niScope_Fetch

Table 1.

will read the strings content and call correct functions for the instrument.

Keeping things simple and streamlining the parsing process, we used a command followed by name value pair format:

<Command>: [<Name>=<Value>] [,<Name>=<Value>]

Example:

ConfigureVertical: Channel= 1, Coupling= DC, Attenuation= 0, Range= 10, Offset= 0

For the project, we used the above commands (Table 1) mapping them to function calls.

Creating the Command Processor

Next, we created a wrapper application in VB.NET®. This allowed us to create an instance of a NI-Scope and control it using text based commands over TCP/IP. Now we can control this scope from any computer on our local network.

Note: While I was testing the code, I could even control the NI-Scope using commands in my web browser.

Sample Code:

```
Public Overrides Function Command(ByVal CMD As String) As String

 If UCase(CMD).Contains(“IDN:”.ToUpper) Then
    Return myScope.Identity.InstrumentModel
    Exit Function
 End If

 If UCase(CMD).Contains(“Reset:”.ToUpper) Then
    If Me.Reset() = 0 Then
       Return “Success”
    Else
       Return “ERROR!”
    End If
    Exit Function
 End If

 If UCase(CMD).Contains(“SelfTest:”.ToUpper) Then
    Dim Result As Integer = Me.SelfTest()
    If Result = 0 Then
       Return “Pass”
    Else
       Return “Fail! Code -” & Result
    End If

    Exit Function
```

```
  End If

  If UCase(CMD).Contains("SelfCal:".ToUpper) Then
    Dim Result As Integer = Me.SelfCal()
    If Result = 0 Then
      Return "Pass"
    Else
      Return "Fail! Code -" & Result
    End If

    Exit Function
  End If

  If UCase(CMD).Contains("ConfigureChanCharacteristics:".ToUpper) Then
    If Me.ConfigureChanCharacteristics(CMD) = 0 Then
      Return "Done"
    Else
      Return "ERROR!"
    End If
  End If

  If UCase(CMD).Contains("ConfigureVertical:".ToUpper) Then
  If Me.ConfigureVertical(CMD) = 0 Then
  Return "Done"
  Else
  Return "ERROR!"
  End If
  End If

  If UCase(CMD).Contains("ConfigureHorizontalTiming:".ToUpper) Then
    If Me.ConfigureHorizontalTiming(CMD) = 0 Then
      Return "Done"
    Else
      Return "ERROR!"
    End If
  End If

  If UCase(CMD).Contains("ConfigureEdgeTrigger:".ToUpper) Then
    If Me.ConfigureEdgeTrigger(CMD) = 0 Then
      Return "Done"
    Else
      Return "ERROR!"
    End If
  End If

  If UCase(CMD).Contains("ConfigureImmediateTrigger:".ToUpper) Then
    If Me.ConfigureImmediateTrigger() = 0 Then
      Return "Done"
    Else
      Return "ERROR!"
    End If
  End If

  If UCase(CMD).Contains("Commit:".ToUpper) Then
    If Me.Commit() = 0 Then
      Return "Done"
    Else
      Return "ERROR!"
    End If
  End If

  If UCase(CMD).Contains("Measure:".ToUpper) Then
    Dim Result As Double = Me.Measure(CMD)
    Return Result
    Exit Function
  End If

  Return "ERROR! Command Not Processed!"
  Exit Function

End Function
```

Exposing the Command Processor

This was the coolest part of the code. Notice the Overrides in the function call listed below:

```
Public Overrides Function Command(ByVal CMD As String)
As String
```

This function overrides the base class function that uses the Operating Contract and WebGet attributes:

```
<OperationContract()>
<WebGet(ResponseFormat:=WebMessageFormat.Xml,
BodyStyle:=WebMessageBodyStyle.Bare)>
Public MustOverride Function Command(ByVal CMD As
String) As String
```

This makes creating a web interface for the above command process a as simple as:

```
' Create New host
Dim host = New WebServiceHost(handler, New Uri("http://" &
Me.IP & ":" & Me.Port))
Dim EP = host.AddServiceEndpoint(GetType(iTxtCommand),
New WebHttpBinding(), Name)
host.Open()
```

Creating The MCNETCOMM.EXE

Now that the code UUT command processing code is written and a service has been enabled, the next thing we need is a link from MET/CAL®. Because we wanted the software to be backward compatible, we chose to write an executable that could exchange data between MET/CAL®using the dosdose.dat file and the DOS FSC.

The McNetComm.exe we designed will support versions of MET/CAL® from 5.0 and up to and including 8.x version. We also created the executable to be COM visible. This will allow new versions of MET/CAL® to access the MSB™ using the LIB FSC in place of the DOS FSC.

The MET/CAL® Procedure

Like all of our procedures, we like to calibrate more with less code, so this procedure supports our standard MET/CAL® programming model with the Test Points Sub calling the Test Routines sub. I want to keep this paper short, so if you have questions on this model, you can read my paper on "Rethinking the Flexible Standards Paradigm" found at http://www.callabsolutions.com/category/papers-articles/.

As we build the communication and control portion of our MET/CAL® procedure, we were able to simplify thinks by keeping a set of global variables storing the state of the instrument. Then we could simply call a configure instrument call that would set the UUT up as required for the test.

First, we would call the Default Test Configuration resetting the global variables:

```
3.001  LABEL      Default
# Channel Settings
3.002  MATH       @Channel    = 1
3.003  MATH       @Impedance  = 1e6
3.004  MATH       @Bandwidth  = 100e6
3.005  MATH       @Coupl      = "'DC'"
3.006  MATH       @Atten      = 1
```

```
3.007  MATH       @Range     = 4
3.008  MATH       @Offset    = 0
3.016  MATH       @AVG       = 8
# Horizontal Settings
3.009  MATH       @SampleRate = 10e6
3.010  MATH       @Position   = 50
3.011  MATH       @Points     = 100e3
#Trigger Settings
3.012  MATH       @TChannel   = 1
3.013  MATH       @Slope      = "'POS'"
3.014  MATH       @TCoupl     = "'DC'"
3.015  MATH       @Level      = 0.00125
```

With each test group we would set the Test Channel:

```
3.002  MATH       @Channel    = <Test Channel>
```

And every point we set the required variables and execute the test:

```
#----------------------------
10.005  MATH       @Volts=0.09*1
10.006  MATH       @Range=0.2*1
10.007  VSET       UUT_Res = .001
10.008  IF         Find(S[23],"EnableRepeatability",1)>0
10.009  VSET       U3 = 0
10.010  ENDIF
10.011  CALL       NI 51xx Sub Test Routines-Conf
10.012  MATH       L[9]=Fld(S[31],2,"Unc=")/1
10.013  ACC        0.000%_     L9U
10.014  IF         1==0
10.015  TARGET     -m
10.016  CALL       NI 51xx Sub Test Routines-Meas
10.017  ENDIF
10.018  MATH       MEM=Fld(S[31],2,"Value=")/1
10.019  MEMCX  0.2   %_        0.65U
```

The test routines would configure the UUT using the following Sub Tools Calls:

```
# Set up the Channel
3.023  MATH       S[30]="ConfChanChar"
3.024  CALL       NI 51xx Sub Tools
3.025  MATH       S[30]="ConfVert"
3.026  CALL       NI 51xx Sub Tools
```

The Sub Tools then passes the commands to the UUT as follows:

```
#====================================================
7.001  LABEL      ConfChanChar
7.002  MATH       MEM2 = "ConfigureChanCharacteristics:"
7.003  MATH       MEM2=MEM2& " Channel= " & @Channel
7.004  MATH       MEM2=MEM2& ",Impedance= " & @Impedance
7.005  MATH       MEM2=MEM2& ",Bandwidth=" & @Bandwidth
7.006  DOS        C:\CLS\McNetComm.exe Query UUT

7.007  IF         Find(MEM2,"Configure",1)
7.008  DISP       Communication Error Command Not Executed
7.009  ENDIF
7.010  END
#====================================================
8.001  LABEL      ConfVert
8.002  MATH       MEM2 = "ConfigureVertical: "
8.003  MATH       MEM2=MEM2& " Channel=" & @Channel
8.004  MATH       MEM2=MEM2& ",Coupling=" & @Coupl
8.005  MATH       MEM2=MEM2& ",Attenuation=" & @Atten
8.006  MATH       MEM2=MEM2& ",Range= " & @Range
8.007  MATH       MEM2=MEM2& ",Offset= " & @Offset
8.008  DOS        C:\CLS\McNetComm.exe Query UUT

8.009  IF         Find(MEM2,"Configure",1)
8.010  DISP       Communication Error Command Not Executed
8.011  ENDIF
8.012  END
```

Conclusion

So why does all this work? It is not just because it is neat—ironically I write more code so that I can write less code. Most developers and managers don't see the cost for code support and re-writes. We look at our software with respect to support and life expectancy. To be successful as a software development organization in the metrology world, we have to produce quality software solutions that can stand the test of time.

Creating an additional layer to our procedures, the Metrology Service Bus™, will allow greater flexibility. Adding a simple command processer to our software based instruments allows us to control them remotely. In the end as a company we have de-siloed our software, opening up a world of possibilities.

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This paper was previously presented at the Measurement Science Conference (MSC) in Long Beach, March 14, 2014, http://www.msc-conf.com.

NEW PRODUCTS AND SERVICES

NIST High-Power Laser Calibration Facility

The National Institute of Standards and Technology (NIST) has launched a new calibration service for high-power lasers of the sort used by manufacturers for applications such as cutting and welding metals, as well as by the military for more specialized applications like defusing unexploded land mines.

NIST is the only national metrology institute in the world to offer calibrations for laser power and power meters above 1.5 kilowatts (kW). The new service is offered for power levels up to 10 kW. Light focused from a 10 kW laser is more than a million times more intense than sunlight reaching the Earth.

NIST recently completed its first high-power calibration, for a commercial 5 kW laser power meter. The measurement had an uncertainty of about one percent over two standard deviations, the accuracy and precision threshold necessary for military and advanced manufacturing applications. "That level of uncertainty at multi-kilowatt levels is unprecedented," calibration leader Josh Hadler says. Laser output must be known exactly to achieve effective, safe performance in virtually all applications at these power levels.

To establish the new service, NIST staff bought a 10 kW fiber laser and extensively renovated a laboratory to meet electrical requirements and add appropriate safeguards such as walls with high damage tolerance and special optics and beam controls for the laser. Operators view the running laser from behind a protective barrier, using a multi-camera system for monitoring and control. Laser light is absorbed by a conventional calorimeter surrounded and cooled by flowing water. Staff measure the temperature difference between the incoming and outgoing water and use that value to calculate the laser power.

In addition to calibrations, NIST plans to use the new facility for research on the fundamental physical processes that occur during laser welding, which is often less expensive and hazardous than comparable conventional welding techniques. The study could help overcome technical challenges such as welding of materials that are dissimilar or have different thickness, potentially boosting the use of this technology and saving money for U.S. manufacturers. The ability to join dissimilar materials with greatly different properties would help overcome longstanding design and cost hurdles associated with welding.

NIST is developing faster and more portable laser power meters for use with kilowatt lasers, which may eventually be used as transfer standards for the new service, project leader Paul Williams says. These innovations could enable NIST-calibrated measurements of high-power lasers to be performed in commercial labs or national metrology labs in other countries.

For technical descriptions of NIST laser calibration services and staff contact information, see www.nist.gov/pml/div686/calibrations/laser.cfm.

Source: *NIST Tech Beat*: October 29, 2014, http://www.nist.gov/pml/div686/20141029_laser_cal.cfm.

NIST's new calibration service for high-power lasers is controlled from behind a protective barrier. The laser is monitored by a camera and is visible in the upper left corner of the right-hand screen. Paul Williams (left) and Joshua Hadler operate the service, which can calibrate lasers with up to 10 kilowatts of power for manufacturers and military customers.
Credit: Burrus/NIST

Fluke Calibration 9118A Thermocouple Calibration Furnace

Fluke Calibration introduces the 9118A Thermocouple Calibration Furnace, a horizontal, open-ended tube furnace with a temperature range of 300 to 1200 degrees Celsius. The 9118A enables calibration professionals to conduct comparison calibrations of the noble- and base-metal thermocouples used in a variety of industries, including aerospace, automotive, energy, metals, and plastics.

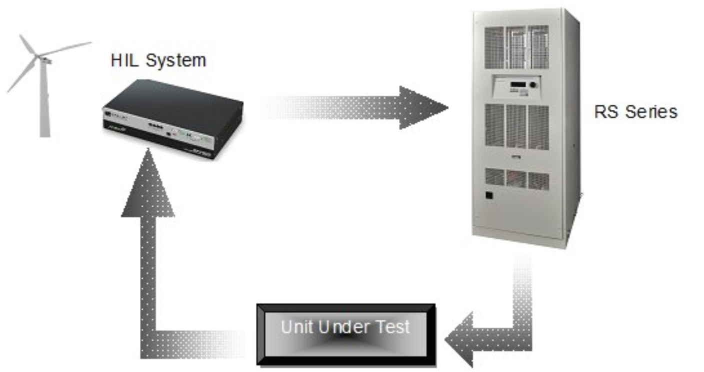
Calibrations can be fully automated when the 9118A is used with the Fluke Calibration 1586A Precision Temperature Scanner, increasing lab productivity.

The 9118A can be operated with or without an isothermal block, increasing the workload that can be performed with a single unit. The furnace configuration can be quickly changed by selecting parameters stored in the controller and by either inserting or removing the alumina-ceramic isothermal block.

It features temperature stability of plus-or-minus 0.1 degrees at 1200 degrees Celsius with a radial uniformity of plus-or-minus 0.25 degrees at 1200 degrees Celsius and axial uniformity of plus-or-minus 0.2 degrees at 1200 degrees Celsius. The wide temperature range of the calibration furnace enables labs to meet standards like AMS2750 and EURAMET cg-8 that require thermocouples be calibrated over the full temperature range in which they are used.

The 9118A manages its heater power to prevent heater elements from overheating, improving the reliability of the furnace and extending its lifetime. Its non-metallic block minimizes thermocouple contamination and eliminates the need to protect the thermocouples under test with costly ceramic sleeving, reducing the cost of ownership.

To learn more about the Fluke Calibration 9118A Thermocouple Calibration Furnace, visit http://www.flukecal.com/9118A.



California Instruments RS Series External Drive Option

AMETEK Programmable Power, the global leader in programmable AC and DC power test solutions (www.programmablepower.com), has released the External Drive (-EXTD) option for its California Instruments RS Series of high-power regenerative programmable AC sources. The External Drive option gives users a simple, low-cost way to directly control the output of an RS Series power source in real time, enabling them to be more easily used in hardware-in-the-loop (HIL) test systems.

Hardware-In-the-Loop (HIL) is a technique used in the development and test of complete real-time embedded systems. Using HIL techniques allows simulation of real-time feedback and control of such complex systems. HIL applications require electrical interface to act as the interface to embedded systems and the equipment under test. HIL is commonly used to prototype systems for power grids, power electronics and hybrid electric drives. The most recent trend is modeling dispersed energy products, such as a PV inverter, and their effects to the utility grid.

The RS Series features advanced digital signal processing (DSP) control technology to the power amplifiers within the source. The source features traditional remote control methods, such as GPIB or LAN that inherently introduces control delays in the hundreds of milliseconds, which do not simulate real-time control. The introduction of EXTD allows real-time control via analog signal so delays are typically reduced to 100 microseconds (figure 1), which is 1,000 times faster than the delay time of controlling the output via GPIB or LAN ports. EXTD essentially allows the RS to be used as a high bandwidth amplifier, while the internal DSP continues to monitor the output in order to ensure safe operation.

Available with outputs ranging from 90 kVA to 1MVA, the RS is the latest series of products to use AMETEK's high-performance, pulse-width modulation (PWM) switching technology to provide advanced performance solutions for AC power test applications.

Additional details about the RS-EXTD can be found on the AMETEK Programmable Power web site, including anEXTD technical note and user's manual.

About AMETEK Programmable Power For more information on any of the AMETEK's programmable power supplies and programmable loads, contact AMETEK Programmable Power Sales toll free at 800-733-5427 or 858-458-0223, or by email at sales.ppd@ametek.com. Users also can contact an authorized AMETEK Programmable Power sales representative, who can be located by visiting programmablepower.com/contact/

Keysight Technologies UXA Signal Analyzer

Keysight Technologies, Inc. announced the new flagship of its X-Series: the N9040B UXA signal analyzer. The UXA delivers industry-leading phase noise performance as well as 510-MHz analysis and real-time bandwidths. Combining these three capabilities with a large display and touch-driven interface, the UXA provides wider, deeper views of elusive wideband signals—known or unknown.

In the development of mission-critical radar, electronic-warfare and communication systems, leading-edge signal analysis requires excellent phase noise performance. Keysight's proprietary local-oscillator (LO) technology achieves phase noise of -136 dBc/Hz at 1 GHz, 10 kHz offset, and -132 dBc/Hz at 10 GHz, 100 kHz offset.

The maximum analysis bandwidth of 510 MHz can be used across the full frequency range with excellent spurious-free dynamic range (SFDR) of >75 dBc. This enables accurate characterization of parameters such as wideband chirp linearity.

When monitoring or capturing highly elusive signals, the optional 510-MHz real-time spectrum analysis capability provides 100-percent probability of intercept (POI) for durations as short as 3.84 μs.

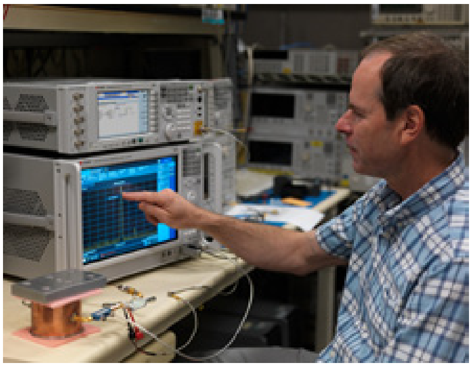
"Built on our unique technology, the UXA delivers unsurpassed purity and clarity in signal analysis," said Andy Botka, vice president and general manager of Keysight's Microwave and Communications Division. "The unprecedented quality of its IF section enables a designer to understand what's happening inside their system and helps them prove that it's meeting or exceeding its performance goals."

Through a 14.1-inch screen, the UXA allows the user to view results using an array of flexible measurement displays. Based on the familiar X-Series menu structure, the touch-driven interface supports gestures and simplifies measurement and analysis by placing most setup items no more than two taps away.

For detailed signal analysis, the UXA supports the Keysight 89600 VSA software. With support for more than 75 standards and formats, the 89600 VSA makes it possible to see through the complexity of challenging signals in radar, EW and communication applications including 5G.

In secure environments, features such as a removable solid-state drive ensure compliance with the most stringent requirements.

More information is available online at www.keysight.com/find/UXA.



Thyracont Vacuum Transducers

All transducers of the Smartline product family from Thyracont, a manufacturer of measurement instrumentation, are now available with EtherCAT interface.

EtherCAT is currently the fasted industrial Ethernet technology and convinces with easy handling. For instance manual address settings are not necessary and a diagnosis for localizing errors are already included.

Smartline transducers with EtherCAT can be easily integrated in existing networks. Due to a flexible topology the EtherCAT network is variable and extendable and provides access to further internet technologies.

Smartline transducers cover the range from atmosphere to ultrahigh vacuum with outstanding precision, offer durable exchangeable sensor heads and robust full metal housings.

Thyracont Vacuum Instruments GmbH manufactures high quality vacuum measurement and control instruments for the whole measuring range from rough to ultra high vacuum. Customers include manufacturers of vacuum pumps and vacuum systems, process and equipment engineers in industry, laboratories, universities and research institutes. www.thyracont.com

Static Solutions Inc. ESD Ultimat™ Rubber/Table Mat

Ultimat™ is a new static dissipative industrial grade two-layer elastomer designed for use on tables and other grounded work bench surfaces. Its electrical properties are volume dissipative unlike many of the surface dissipative properties of the competition. This material was developed to conform to the new Class Zero and RoHS requirements.

- Lifetime electrical warranty
- Chemical and temperature resistant
- No odor, low VOC
- Static dissipative
- Lays flat, no curl
- 2.0mm (.080") thick
- ROHS, ISO, CE, and NIST compliant
- Industrial grade cross-linked rubber
- Available in light blue, dark blue, gray, black, green, and white
- 24", 30", 36", and 48" wide; 40' long

Ultimat™ is a chemically cross-linked material with different electrical resistances on both surfaces. Because it is inherently cross-linked, the material will not delaminate and is volume conductive. The layers are permanently dissipative with "space age dissipative polymers" which will not lose its electrical properties, not exudate, and more important will not outgas and contaminate in clean room environments. The material is as durable as rigid laminates and as comfortable and appealing as the softer rubber mats. Works well with constant monitors (specifically the CM-1701). Because of its structure the material meets both the EOS 20/20 and European IEC 613450-5-1 specifications and therefore has outstanding charge dissipation, rapid charge decay, no charge suppression and outstanding low tribogeneration properties. The material will withstand solvents, soldering iron deformation, not curl, and have excellent abrasion resistance. The embossed surface will reduce light glare, increase part slip resistance, and facilitate cleaning. Since the material is free from halogens, lead, arsenic, barium, heavy metals, and other dangerous volatiles it may be used in environments where outgassing and contamination is of concern.

Please call Static Solutions to find out more about our variety of table mats, we are willing to send small samples of them as well.

Static Solutions is a USA global manufacturer of ESD and clean room products for over 30 years. The company sells a full complete line of leading edge ESD products in all three continents through distribution and sales representatives throughout the America, Europe, and Asia. http://staticsolutions.com/

Fluke Calibration 6003A

Fluke Calibration introduces the 6003A Three Phase Electrical Power Source, a cost-effective instrument that provides the superior accuracy and performance of three independent phases in one compact device. The 6003A is accurate enough for calibration laboratories, with specifications of plus-or-minus 0.038 percent for power and plus-or-minus 0.01 degree for phase. Its compact form factor also makes it easy to transport and maintain in organizations that manufacture, maintain, and calibrate power meters, energy meters, power quality analyzers, and similar tools.

The 6003A delivers the accuracy and features found in more expensive three-phase systems. It provides three independent phases of precise voltage and current. It also sources power quality phenomena, including harmonics, interharmonics, and dip/swell variations. It includes measurement capabilities for dc voltage, dc resistance, and frequency for measuring outputs from power and energy transducers.

Because it's a single instrument, the 6003A is easier to transport to test workloads in situ, takes up less bench space, and is more cost effective to maintain than multi-piece units. Its graphical user interface enables users to set up complex harmonic signals quickly and easily.

Specialized capabilities can be added, including an energy option, which adds a pulse counter and pulse output; a power quality option that enables the 6003A to calibrate power quality instrumentation by generating up to 63 harmonics, an interharmonic, modulation (flicker), and dips and swells on all three channels; and a 90 A adapter with high-current leads that generates up to 90 A from a single current phase to manage high-current workloads.

To learn more about the Fluke Calibration 6003A Three Phase Electrical Power Source, visit www.flukecal.com/6003a.

Rohde & Schwarz ZND Vector Network Analyzer

The new R&S ZND vector network analyzer from Rohde & Schwarz features two test ports, and the base unit is designed for unidirectional measurements from 100 kHz to 4.5 GHz. Its easy-to-use options provide for flexible upgrades. The frequency range can be extended to 8.5 GHz, plus the instrument can be equipped for bidirectional measurements up to 4.5 GHz or 8.5 GHz. These functions can be locally activated.

The R&S ZND is perfect for production line measurements such as characterization of passive mobile phone components. The analyzer enables users to easily measure S-parameters such as S11 on antennas or S21 on filters. The favorably priced, easy-to-operate instrument is also ideal for training purposes. The R&S ZND offers a specified dynamic range of up to 120 dB and a specified power sweep range of up to 48 dB. Options for time domain measurements, general purpose interface bus (GPIB) and a parts handler interface (handler I/O) are also available.

The analyzer's large 30 cm (12.1") touchscreen and intuitive user interface make it especially easy to configure measurements and analyze results. All instrument functions are accessible in no more than three operating steps via the soft panel. A toolbar and drag and drop functionality allow users to configure the R&S ZND very quickly, and touchscreen tabs make it simple to switch between instrument setups. Traces and channels can be arranged in any desired combination, enabling users to display results in a clear and straightforward manner even for complex measurements.

With the R&S ZND vector network analyzer, Rohde & Schwarz is expanding its Value Instruments portfolio of attractively priced, high-quality T&M equipment. The instrument is now available from Rohde & Schwarz.

IEST Recommended Practice and ISO 14644 Standards

As the weather turns cold in the Midwest, experts within the Institute of Environmental Sciences and Technology (IEST) are just starting to get warmed up, with the recent release of a new Recommended Practice and three ISO 14644 Standards aimed at improving day-to-day operations for contamination control professionals.

Years of review, revision, and debate among industry experts led to the release of:

- ISO/DIS 14644-1.2 – Cleanrooms and associated controlled environments – Part 1: Classification of air cleanliness by particle concentration. Replacing the Draft International Standard of 2010, this standard specifies requirements for testing and monitoring of a cleanroom or clean zone. The document provides the test method to determine the concentration of airborne particles at each test location. The new draft differs from the old version in the method of determining the number of sample locations that must be tested to comply with the standard. This new method is based on a statistical sampling approach and is a significant change from the previous standard.
- ISO/DIS 14644-2.2 – Cleanrooms and associated controlled environments – Part 2: Monitoring to provide evidence of cleanroom performance related to air cleanliness by particle concentration. This draft is much different than the previous versions. The new DIS Standard addresses monitoring of cleanroom performance with regard to the airborne particulate cleanliness of the cleanroom.
- ISO/DIS 14644-14 – Cleanrooms and associated controlled environments – Part 14: Assessment of suitability for use of equipment by airborne particle concentration. This part of ISO 14644 specifies a methodology to assess the suitability of equipment (e. g., machinery, measuring equipment, process equipment, components, tools) for use n cleanrooms and associated controlled environments, with respect to airborne particle cleanliness as specified in ISO 14644-1.
- IEST-RP-CC036.1 – Testing Fan Filter Units. This Recommended Practice (RP), IEST-RP-CC036.1, covers the methods and definitions for testing the performance of fan filter units. The document provides customers and suppliers of fan filter units the necessary test protocols for measuring performance in such a manner as to allow direct comparison of units of varying designs and operating features provided by different manufacturers.

These documents are now available for purchase through IEST, which has more than 60 Working Groups developing and revising Recommended Practices. For more information, visit the ISO 14644 or Recent Publications pages at www.iest.org.

Isotech ISOCAL 6 Calibrators

Isotech is pleased to announce a new range of portable calibrators for the calibration of RTDs, Thermocouples, Thermostats, Thermistors and Process Inputs. The range spans -45 to 1200° C with models that can be used as Dry Blocks and Stirred Liquid Baths. There are options to calibrate infrared thermometers, surface sensors and even to operate ITS-90 Fixed Point Cells.

We have been providing calibration solutions for more than 30 years, from Primary Standards for National Metrology Institutes through to handheld calibrators for service engineers.

These new advanced models add extra features bringing benefits of greater performance, more input channels, advanced logging and remote monitoring with a bright full color display.

Data can be logged to a USB Memory Drive or internal memory and opened directly in Microsoft ExcelTM. There is also an option to save data in a secure tamper proof format with support software to manage the data.

Automatic temperature cycling saves time and money with the calibrator automatically logging data over a series of calibration points.

http://www.isotechna.com/

The Cons of Automation

Michael Schwartz
Publisher

You will usually hear me talking about all the great things that automation brings. And for the most part automation is good. But it is not without its drawbacks and so, with this article, I would like to highlight some of the downsides to automation. I hope, as automation evolves, we can find some balance between the good things that automation brings vs. the side effects of dependence.

I started thinking about the side effects of automation the other day when I was making a cup of coffee of at the dentist's office. I was using one of those pod based coffee makers that have become ubiquitous. I didn't understand 100% why they were so popular at first, until I began to see how convenient and easy they make everything—from coffee to hot chocolate—with no mess and no measurement during the process! We have automated the measurement process out of making something so simple as a cup of tea or coffee.

This got me to thinking about measurements and automation in general. As an automation engineer, am I doing harm to the measurement community as a whole? Will the technicians of the future forget how to make even the simplest of measurements? Will the work of metrology be compressed to the auto set features on a piece of test equipment?

I remember this was a very important issue for my grandmother, back when I purchased my first digital watch. She was so concerned kids would never learn to tell time. Same thing with my mom when the school said I had to have a calculator for my high school science classes. I know generations before me learned science using slide rules. But what skills have I never learned because I had a digital watch and a calculator?

If you think about it, there are a lot skills you learn reading a clock. You have to know AM & PM and how to convert those values to a 24 hour clock. It is a simple skill, but once mastered you can add 12 to any number. Then the little hand helps you master your times 5 tables, as well as fractions, because 15 minutes into a 60 minutes is a quarter hour. And if you think about it from a higher math level, you learned both base 12 and base 60, and so on… creating new neural pathways in your brain.

Now from a quality perspective, metrology & automation is how you are able to get the same hamburger at every McDonald's location. But from an education and culinary perspective, many of their people can't cook outside of their automated system.

So where is the line in the sand? How will we know when we have moved too far towards the automated site or quality? Where is that point of no return?

I would like to see more of a mixture of automation and training! I didn't always think this way. But over the years I have learned when automation breaks, the system needs to have a few people who really know what is going on. The problem is those people grew up without digital watches, calculators and a computer program that did the work for them.

Looking at the Army's ICE (Integrated Calibration Environment), I see huge value in their paradigm towards automation. Being the first branch of the US Military to embrace automation, they had a unique problem. Automation was new to everyone, so many things went wrong. Even though most of them were related to user errors, it was the same issue as if the automation didn't function properly—work got backed up and the Army could not complete their mission.

So the US Army did something very unique. They created written calibration procedures then automated them to their manual calibration document. This allowed the technician in the field to either test the device manually or automated. But more important, it allowed a non-commissioned officer to say "do it manually so that you know how to do this test!"

Metrology as a whole can never be compressed into a pure production mentality. We need to build skills in our junior technicians so that they can become senior technicians and someday metrology engineers. We can't rely 100% on automation! We need quality training programs that co-exist right alongside of our press-this-button-and-go automation. ❧

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