CAL LAB

THE INTERNATIONAL JOURNAL OF METROLOGY

2022
JANUARY
FEBRUARY
MARCH

Overview of the ISO/IEC 17025 Revision Process

ENOB: The Best Digitizer Performance Metric

Additive Manufacturing: New Frontiers for Production & Validation

PRECISION CURRENT INSTRUMENTATION AND CURRENT CALIBRATION

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VOLUME 29, NUMBER 1

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FEATURES

DEPARTMENTS

ON THE COVER: Steve is calibrating a Keysight N6700 series power supply at the Electro Rent calibration facility in Van Nuys, California.

CALENDAR

UPCOMING CONFERENCES & MEETINGS

The following scheduled events are subject to change. Visit the event URL provided for the latest information.

Apr 3-6, 2022 A2LA Tech Forum. Chantilly, VA. Be part of one of the accreditation industry's largest annual events! https://a2la.org/

Apr 7-8, 2022 METROMEET (Hybrid). Bilbao, Spain. METROMEET is a unique event and the most important conference in the sector of Industrial Dimensional Metrology. https://metromeet.org/

Apr 25-28, 2022. CAFMET. Casablanca, Morocco. CAFMET 2022 est la 8ème Conférence Internationale de Métrologie. CAFMET 2022 est programmée du 25 au 28 avril 2022 à Casablanca. De nombreuses conférences et plusieurs ateliers vous attendent. https://www.cafmet-conference.com/

Apr 25-28, 2022 FORUMESURE. Casablanca, Morocco. FORUMESURE est une exposition organisée annuellement. Celle-ci est libre d'accès et permet à des entreprises et à des laboratoires d'exposer leurs activités et leurs produits et services, ainsi que leurs dernières innovations. http://www.forumesure.com

May 10-12, 2022 SENSOR+TEST. Nürnberg, Germany. SENSOR+TEST is one of the major international scientific forums for sensors, measuring and testing technologies where researchers and other professionals from all over the world meet to discuss new technologies and the latest processes. https://www.sensor-test.de/

May 16-19, 2022 MSC Training Symposium. Anaheim, CA. The annual symposium provides measurement professionals the opportunity to provide a training session of related subjects within the measurement industry and share the knowledge gained through education or on-the-job training. https://msc-conf.com/

May 16-19, 2022 I2MTC. Ottawa, Canada. The IEEE International Instrumentation and Measurement Technology Conference – is the flagship conference of the IEEE Instrumentation and Measurement Society and is dedicated to advances in measurement methodologies, measurement systems, instrumentation and sensors in all areas of science and technology. https://i2mtc2022.ieee-ims.org/

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EDITOR'S DESK

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

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Old Is New

Well, what is new… NCSLI Technical Exchange started online this month. They had to scrap their original plan of in-person training in Houston, TX, amidst the latest wave of COVID-19. As usual, they have a quality line-up of tutorials on a variety of topics and disciplines: force, proficiency testing, instrumentation primer, internal auditing, temperature… the list goes on. So head over to https://ncsli.org/page/tep for details and registration!

A2LA has their Tech Forum (TEFO22) in April at Westfields Marriott in Chantilly, VA. And, MSC Training Symposium is coming up in May at the Hilton in Anaheim, California. Check out the Calendar section for details and more events. There's plenty of opportunity to learn something new!

Speaking of new, we have a new contributor, Dan Wiswell, who will be sharing with us his knowledge of vintage and antique measurement instruments in each issue. Maybe you've seen Dan on LinkedIn and followed his unique postings of various wooden-cased Weston meters and other goodies. He can be found with #indaysofold. So, it is no coincidence this issue debuts a new Department called "In Days of Old" with a condensed history of measuring instruments. I think you'll probably learn something new.

For feature articles, we start with an introduction to understanding ISO/IEC 17025, "Overview of the ISO/IEC 17025 Revision Process," by Diane Baldi and Heather Wade. This introduction is an excerpt from their downloadable e-book, details of which follow the article.

Next, Andrew Dawson, of Vitrek, shows how noise is mathematically removed on digitized signals in "ENOB: The Best Digitizer Performance Metric." These techniques can be applied to other digital measurement related issues.

And finally, we found an interesting article by Peter de Groot with Zygo Corporation, on "Additive Manufacturing: New Frontiers for Production & Validation." Metrology is present in every form of engineering, which often requires novel methods of measurement for the production of critical applications.

I hope you enjoy this first issue of the New Year!

Happy Measuring,

Sita Schwartz

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May 17-20, 2022 GAS Analysis Symposium & Exhibition. Paris, France. The leading international symposium and exhibition for gas analysis, manufacturers, technical staff and end-users, presenting you the latest developments in laboratory, process analysis, metrology and sensor technology and their applications. https://www.gasanalysisevent.com/

May 25-27, 2022 MetroLivEnv. Cosenza, Italy. The 2022 IEEE International Workshop on Metrology for Living Environment (IEEE MetroLivEnv 2022) aims to be a solid reference of the technical community to present and discuss the most recent results of scientific and technological research for the living environment, with particular emphasis on applications and new trends. https://www.metrolivenv.org/

Jun 7-9, 2022 MetroInd4.0&IoT. Trento, Italy. MetroInd4.0&IoT aims to discuss the contributions both of the metrology for the development of Industry 4.0 and IoT and the new opportunities offered by Industry 4.0 and IoT for the development of new measurement methods and instruments. https://www.metroind40iot.org/

Jun 15-17, 2022 CIVEMSA. Chemnitz, Germany. IEEE 9th International Conference on Computational Intelligence and Virtual Environments for Measurement Systems and Applications (CIVEMSA). https://conferences.ieee.org/conferences_events/conferences/conferencedetails/53371

Jun 19-24, 2022 International Microwave Symposium (IMS). Denver, CO. IMS is the flagship event in a week dedicated to all things microwaves and RF. The week also includes the IEEE MTT-S Radio Frequency Integrated Circuits Symposium (RFIC) and the Automatic Radio Frequency Techniques Group (ARFTG). https://ims-ieee.org/

Jun 24, 2022 99th ARFTG Microwave Measurement Conference. Denver, CO. The Automatic Radio Frequency Techniques Group (ARFTG) is a technical organization interested in all aspects of RF and microwave test and measurement. https://www.arftg.org/
Aug 20-25, 2022 NCSL International Workshop & Symposium. Grapevine, TX. https://ncsli.org/

Aug 29-Sep 1, 2022 AUTOTESTCON. National Harbor, MD. AUTOTESTCON is the world's premier conference that brings together the military/aerospace automatic test industry and government/military acquirers and users to share new technologies, discuss innovative applications, and exhibit products and services. It is sponsored annually by the Institute of Electrical and Electronic Engineers (IEEE). https://2022.autotestcon.com/

SEMINARS & WEBINARS: Dimensional

Mar 22-23, 2022 "Hands-On" Precision Gage Calibration & Repair Training. Bloomington, MN. IICT Enterprises. This 2-day training offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Approximately 75% of the workshop involves "Hands-on" calibration, repair and adjustments of micrometers, calipers, indicators height gages, etc. https://www.calibrationtraining.com/

Mar 22-24, 2022 Dimensional Gage Calibration. Aurora (Chicago), IL. Mitutoyo America's Gage Calibration course is a unique, active, educational experience designed specifically for those who plan and perform calibrations of dimensional measuring tools, gages, and instruments. https://www.mitutoyo.com/training-education/

Apr 6, 2022 Introduction to Dimensional Gage Calibration. Renton, WA. Mitutoyo. The course will thoroughly cover micrometer and caliper calibration, as well as touch on all types of indicators, and in addition, the course will build a base understanding of the principles in dimensional calibration such that the student can extend the concepts to other measuring equipment. https://www.mitutoyo.com/training-education/

Apr 12-13, 2022 "Hands-On" Precision Gage Calibration & Repair Training. Virtual Class. IICT Enterprises. This 2-day training offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Approximately 75% of the workshop involves "Hands-on" calibration, repair and adjustments of micrometers, calipers, indicators height gages, etc. https://www.calibrationtraining.com/

April 27-28, 2022 "Hands-On" Precision Gage Calibration & Repair Training. Las Vegas, NV. IICT Enterprises. This 2-day training offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Approximately 75% of the workshop involves "Hands-on" calibration, repair and adjustments of micrometers, calipers, indicators height gages, etc. https://www.calibrationtraining.com/

May 10-11, 2022 "Hands-On" Precision Gage Calibration & Repair Training. Virtual Class. IICT Enterprises. This 2-day training offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Approximately 75% of the workshop involves "Hands-on" calibration, repair and adjustments of micrometers, calipers, indicators height gages, etc. https://www.calibrationtraining.com/

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May 10-12, 2022 Dimensional Gage Calibration. Aurora (Chicago), IL. Mitutoyo America's Gage Calibration course is a unique, active, educational experience designed specifically for those who plan and perform calibrations of dimensional measuring tools, gages, and instruments. https://www.mitutoyo.com/training-education/

May 24-25, 2022 Precision Gage Calibration & Repair. Indianapolis, IN. IICT Enterprises. This 2-day training offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Approximately 75% of the workshop involves "Hands-on" calibration, repair and adjustments of micrometers, calipers, indicators height gages, etc. https://www.calibrationtraining.com/

May 26-27, 2022 Precision Gage Calibration & Repair. Schaumburg, IL. IICT Enterprises. This 2-day training offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Approximately 75% of the workshop involves "Hands-on" calibration, repair and adjustments of micrometers, calipers, indicators height gages, etc. https://www.calibrationtraining.com/

Jun 7-9, 2022 Dimensional Gage Calibration. Aurora (Chicago), IL. Mitutoyo America's Gage Calibration course is a unique, active, educational experience designed specifically for those who plan and perform calibrations of dimensional measuring tools, gages, and instruments. https://www.mitutoyo.com/training-education/

Jun 8-9, 2022 Precision Gage Calibration & Repair. Atlanta, GA. IICT Enterprises. This 2-day training offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Approximately 75% of the workshop involves "Hands-on" calibration, repair and adjustments of micrometers, calipers, indicators height gages, etc. https://www.calibrationtraining.com/

Jun 14-15, 2022 Precision Gage Calibration & Repair. Virtual Class. IICT Enterprises. This 2-day training offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Approximately 75% of the workshop involves "Hands-on" calibration, repair and adjustments of micrometers, calipers, indicators height gages, etc. https://www.calibrationtraining.com/

Jul 12-13, 2022 Precision Gage Calibration & Repair. Virtual Class. IICT Enterprises. This 2-day training offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Workshop involves "Hands-on" calibration, repair and adjustments of micrometers, calipers, indicators height gages, etc. https://www.calibrationtraining.com/

Jul 19-20, 2022 "Hands-On" Precision Gage Calibration & Repair Training. Akron, OH. IICT Enterprises. This 2-day training offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Approximately 75% of the workshop involves "Hands-on" calibration, repair and adjustments of micrometers, calipers, indicators height gages, etc. https://www.calibrationtraining.com/

Aug 2-4, 2022 Dimensional Gage Calibration. Aurora (Chicago), IL. Mitutoyo America's Gage Calibration course is a unique, active, educational experience designed specifically for those who plan and perform calibrations of dimensional measuring tools, gages, and instruments. https://www.mitutoyo.com/training-education/

Aug 9-10, 2022 "Hands-On" Precision Gage Calibration & Repair Training. Bloomington, MN. IICT Enterprises. This 2-day training offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Approximately 75% of the workshop involves "Hands-on" calibration, repair and adjustments of micrometers, calipers, indicators height gages, etc. https://www.calibrationtraining.com/

Sep 13-14 2022 "Hands-On" Precision Gage Calibration & Repair Training. Virtual Class. IICT Enterprises. This 2-day training offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Approximately 75% of the workshop involves "Hands-on" calibration, repair and adjustments of micrometers, calipers, indicators height gages, etc. https://www.calibrationtraining.com/

Sep 22-23, 2022 "Hands-On" Precision Gage Calibration & Repair Training. Bloomington, MN. IICT Enterprises. This 2-day training offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Approximately 75% of the workshop involves "Hands-on" calibration, repair and adjustments of micrometers, calipers, indicators height gages, etc. https://www.calibrationtraining.com/

SEMINARS & WEBINARS: Education

Jul 21, 2022 Information Session: Metric System Education Resources. NIST. This 1.5 hour session will explore NIST Metric Program education publications and other resources that can be downloaded and freely reproduced by teachers, parents, and students. These resources are helpful to students as they become familiar with metric units, develop measurement quantity reference points, and learn more about SI basics. https://www.nist.gov/pml/weights-and-measures/calendar-events

SEMINARS & WEBINARS: Electrical

Apr 4-7, 2022 MET-301 Advanced Hands-On Metrology. Everett, WA. Fluke Calibration. This course introduces the student to advanced measurement concepts and math used in standards laboratories. The student will learn how to make various types of measurements using different measurement methods. https://us.flukecal.com/training

Jun 13-16, 2022 MET-101 Basic Hands-on Metrology. Everett, WA. Fluke Calibration. This Metrology 101 basic metrology training course introduces the student to basic measurement concepts, basic electronics related to measurement instruments and math used in calibration. https://us.flukecal.com/training

SEMINARS & WEBINARS: Flow

Mar 22-23, 2022 Laboratories: Understanding the Requirements and Concepts of ISO/IEC 17025:2017. Live Online. Hosted by ANAB. This introductory course is specifically designed for those individuals who want to understand the requirements of ISO/IEC 17025:2017 and how those requirements apply to laboratories. The course covers all requirements of the standard with a focus on what laboratory personnel need to know to understand and apply the requirements of the standard. https://anab.ansi.org/training

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Mar 22-24, 2022 Internal Auditing to ISO/IEC 17025:2017 (Non-Forensic). Live Online. Hosted by ANAB. ISO/IEC 17025 training course prepares the internal auditor to clearly understand technical issues relating to an audit. Attendees of Auditing to ISO/IEC 17025 training course will learn how to coordinate a quality management system audit to ISO/IEC 17025:2017 and collect audit evidence and document observations, including techniques for effective questioning and listening. https://anab.ansi.org/training

Apr 6-7, 2022 Calibration of Liquid Hydrocarbon Flow Meters. Online Delivery. National Measurement Institute (NMI, Australia. This two-day course provides training on the calibration of liquid-hydrocarbon LPG and petroleum flow meters. It is aimed at manufacturers, technicians and laboratory managers involved in the calibration and use of flowmeters. https://shop.measurement.gov.au/collections/physical-metrology-training

May 5-6, 2022 Laboratories: Understanding the Requirements and Concepts of ISO/IEC 17025:2017. Live Online. Hosted by ANAB. This introductory course is specifically designed for those individuals who want to understand the requirements of ISO/IEC 17025:2017 and how those requirements apply to laboratories. The course covers all requirements of the standard with a focus on what laboratory personnel need to know to understand and apply the requirements of the standard. https://anab.ansi.org/training

May 10-12, 2022 Internal Auditing to ISO/IEC 17025:2017 (Non-Forensic). Live Online. Hosted by ANAB. ISO/IEC 17025 training course prepares the internal auditor to clearly understand technical issues relating to an audit. Attendees of Auditing to ISO/IEC 17025 training course will learn how to coordinate a quality management system audit to ISO/IEC 17025:2017 and collect audit evidence and document observations, including techniques for effective questioning and listening. https://anab.ansi.org/training

May 17-18, 2022 3004 Understanding ISO/IEC 17025 for Testing and Calibration Labs. Webinar hosted by IAS. Learn about the updated ISO/IEC 17025 Standard. https://www.iasonline.org/training/testing-cal-labs/

May 24-25, 2022 Validation and Verification of Analytical Methods. Live Online. Hosted by ANAB. This course provides an introduction to validation and verification of analytical methods. The common elements of a validation/verification plan and a general approach to performing a validation or verification are presented. https://anab.ansi.org/training

SEMINARS & WEBINARS: General

May 26, 2022 Calibration Certificate Evalution. NIST. This

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2-hour webinar will introduce concepts necessary to successfully implement ISO/IEC 17025:2017 compliant calibration certificates within the laboratory and evaluate service provider certificates for compliance. https://www.nist.gov/pml/weights-and-measures/calendar-events

Jun 27-Jul 1, 2022 Fundamentals of Metrology. Gaithersburg, MD. NIST. The 5-day Fundamentals of Metrology seminar is an intensive course that introduces participants to the concepts of measurement systems, units, good laboratory practices, data integrity, measurement uncertainty, measurement assurance, traceability, basic statistics and how they fit into a laboratory Quality Management System. https://www.nist.gov/pml/weights-and-measures/calendar-events

Aug 22-26, 2022 Fundamentals of Metrology. Gaithersburg, MD. NIST. The 5 day Fundamentals of Metrology seminar is an intensive course that introduces participants to the concepts of measurement systems, units, good laboratory practices, data integrity, measurement uncertainty, measurement assurance, traceability, basic statistics and how they fit into a laboratory Quality Management System. https://www.nist.gov/pml/weights-and-measures/calendar-events

SEMINARS & WEBINARS: Management & Quality

Mar 15-16, 2022 3022 Internal Auditing for all Standards. Webinar hosted by IAS. Training for internal auditors in all organizations with quality systems (labs, inspection bodies, certification bodies, proficiency testing providers). https://www.iasonline.org/training/internal_audit_for_accredited_organizations/

Apr 14, 2022 Document Control and Record Keeping. NIST. This 2-hour webinar will introduce the fundamentals of Laboratory Management System Document Control and Record Keeping that are necessary to successfully implement ISO/IEC 17025:2017. https://www.nist.gov/pml/weights-and-measures/calendar-events

Apr 19-21, 2022 Laboratory Management: How to Run an Effective Lab. Daniel Island, SC. IndySoft's 3-day workshop in Daniel Island, SC is an Executive MBA-level training course designed specifically for lab managers, supervisors, or quality assurance representatives who would like an intensive short course on how to maximize your lab's efficiency and profitability while most effectively leading your most valuable resource - your employees. Targeted to those in calibration, testing, maintenance, quality control, or analytics. https://www.workshop.indysoft.com/

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May 26-27, 2022 3022 Internal Auditing for all Standards. Webinar hosted by IAS. Training for internal auditors in all organizations with quality systems (labs, inspection bodies, certification bodies, proficiency testing providers). https://www.iasonline.org/training/internal_audit_for_accredited_organizations/

SEMINARS & WEBINARS: Mass

Apr 25-May 6, 2022 Mass Metrology Seminar. Gaithersburg, MD. NIST. The Mass Metrology Seminar is a two-week, "hands-on" seminar. It incorporates approximately 30 percent lectures and 70 percent demonstrations and laboratory work in which the participant performs measurements by applying procedures and equations discussed in the classroom. https://www.nist.gov/pml/weights-and-measures/calendar-events

Jul 11-21, 2022 Advanced Mass Seminar. Gaithersburg, MD. NIST. The 9-day, hands-on Advanced Mass calibration seminar focuses on the comprehension and application of the advanced mass dissemination procedures, the equations, and associated calculations. It includes the operation of the laboratory equipment, review of documentary references, reference standards, specifications, and tolerances relevant to the measurements. https://www.nist.gov/pml/weights-and-measures/calendar-events

Aug 1-12, 2022 Mass Metrology Seminar. Gaithersburg, MD. NIST. The Mass Metrology Seminar is a two-week, "hands-on" seminar. It incorporates approximately 30 percent lectures and 70 percent demonstrations and laboratory work in which the participant performs measurements by applying procedures and equations discussed in the classroom. https://www.nist.gov/pml/weights-and-measures/calendar-events

SEMINARS & WEBINARS: Measurement Uncertainty

May 3-4, 2022 3006 Uncertainty of Measurement for Labs. Webinar hosted by IAS. The training includes case studies and discussions, with application of statistical components in practical examples that are frequently encountered by testing laboratories. https://www.iasonline.org/training/uncertainty-of-measurement/

Aug 8-10, 2022 MET-302 Introduction to Measurement Uncertainty. Everett, WA. Fluke Calibration. This course will teach you how to develop uncertainty budgets and how to understand the necessary calibration processes and techniques to obtain repeatable results. https://us.flukecal.com/training

SEMINARS & WEBINARS: Pressure

Apr 25-29, 2022 Advanced Piston Gauge Metrology. Phoenix, AZ. Fluke Calibration. Focus is on the theory, use and calibration of piston gauges and dead weight testers. https://us.flukecal.com/training

May 9-13, 2022 TWB 1061 Principles of Pressure Calibration Web-Based Training. Fluke Calibration. This is a short form of the regular five-day in-person Principles of Pressure Calibration class. It is modified to be an instructor-led online class and without the hands-on exercises. It is structured for two hours per day for one week. https://us.flukecal.com/training

Aug 29-Sep 2, 2022 TWB 1061 Principles of Pressure Calibration Web-Based Training. Fluke Calibration. This is a short form of the regular five-day in-person Principles of Pressure Calibration class. It is modified to be an instructor-led online class and without the hands-on exercises. It is structured for two hours per day for one week. https://us.flukecal.com/training

SEMINARS & WEBINARS: Software

Apr 11-15, 2022 MC-205 MET/TEAM® Asset Management. Everett, WA. Fluke Calibration. This five-day course presents a comprehensive overview of how to use MET/TEAM® Test Equipment and Asset Management Software in an Internet browser to develop your asset management system. https://us.flukecal.com/training

May 3-5, 2022 VNA Tools Training Course. Berne-Wabern, Switzerland. Federal Institute of Metrology METAS. VNA Tools is a free software developed by METAS for measurements with the Vector Network Analyzer (VNA). The software facilitates the tasks of evaluating measurement uncertainty in compliance with the ISO-GUM and vindicating metrological traceability. The software is available for download at www.metas.ch/vnatools. The three day course provides a practical and hands-on lesson with this superior and versatile software. https://www.metas.ch/metas/en/home/dl/kurse---seminare.html

May 9-13, 2022 MC-207 Advanced MET/CAL® Procedure Writing. Everett, WA. Fluke Calibration. This course covers advanced topics and requires an existing knowledge of MET/CAL® calibration software. https://us.flukecal.com/training

May 16-20, 2022 TWB 1051 MET/TEAM® Basic Web-Based Training. Fluke Calibration. This web-based course presents an overview of how to use MET/TEAM® Test Equipment and Asset Management Software in an Internet browser to develop your asset management system. https://us.flukecal.com/training

Jun 6-10, 2022 TWB 1031 MET/CAL® Procedure Development Web-Based Training. Fluke Calibration. Learn to create procedures with the latest version of MET/CAL, without leaving your office. https://us.flukecal.com/training

Jul 11-15, 2022 MC-206 Basic MET/CAL® Procedure Writing. Everett, WA. Fluke Calibration. In this five-day Basic MET/CAL® Procedure Writing course, you will learn to configure MET/CAL® software to create, edit, and maintain calibration solutions, projects and procedures. https://us.flukecal.com/training

Jul 25-27, 2022 MC-203 Crystal Report Writing. Everett, WA. Fluke Calibration. A three-day course on the basics of Crystal Reports using MET/TEAM®. https://us.flukecal.com/training

Aug 15-19, 2022 TWB 1051 MET/TEAM® Basic Web-Based Training. Fluke Calibration. This web-based course presents an overview of how to use MET/TEAM® Test Equipment and Asset Management Software in an Internet browser to develop your asset management system. https://us.flukecal.com/training

Sep 12-16, 2022 MC-207 Advanced MET/CAL® Procedure Writing. Everett, WA. Fluke Calibration. This course covers advanced topics and requires an existing knowledge of MET/CAL® calibration software. https://us.flukecal.com/training

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SEMINARS & WEBINARS: Temperature & Humidity

Mar 22-24, 2022 Temperature Measurement. Lindfield NSW, Australia. NMI. This three-day course (9 am to 5 pm) covers the measurement of temperature and the calibration of temperature measuring instruments. It incorporates extensive hands-on practical exercises. https://shop.measurement.gov.au/collections/physical-metrology-training

Apr 11-13, 2022 Practical Temperature Calibration. American Fork, UT. Fluke Calibration. A three-day course loaded with valuable principles and hands-on training designed to help calibration technicians and engineers get a solid base of temperature calibration fundamentals. https://us.flukecal.com/training

Apr 14-15, 2022 Infrared Calibration. American Fork UT. Fluke Calibration. A two-day course with plenty of hands on experience in infrared temperature metrology. This course is for calibration technicians, engineers, metrologists, and technical experts who are beginning or sustaining an infrared temperature calibration program. https://us.flukecal.com/training

Jun 8, 2022 Testing Temperature Controlled Enclosures. Online Delivery. National Metrology Institute (NMI), Australia. This one day course is for people involved in routine performance testing of temperature-controlled enclosures (oven, furnace, refrigerator and fluid bath). It incorporates an extensive overview and comparison of AS2853 and IEC 60068-3-5 requirements, and it also includes an overview of the medical refrigeration equipment temperature mapping requirement to AS3864.2. https://shop.measurement.gov.au/collections/physical-metrology-training

Sep 12-14, 2022 Advanced Topics in Temperature Metrology. American Fork, UT. Fluke Calibration. A three-day course for those who need to get into the details of temperature metrology. This course is for experienced calibration technicians, metrologists, engineers, and technical experts working in primary and secondary-level temperature calibration laboratories who would like to validate, refresh, or expand their understanding of advanced topics in temperature metrology. https://us.flukecal.com/training

SEMINARS & WEBINARS: Vibration

Apr 5-7, 2022 Fundamentals of Random Vibration and Shock Testing. San Jose, CA. This three-day Training in Fundamentals of Random Vibration and Shock Testing covers all the information required to plan, perform, and interpret the results of all types of dynamic testing. Some of the additional areas covered are fixture design, field data measurement and interpretation, evolution of test standards and HALT/HASS processes. https://equipment-reliability.com/open-courses/

Sep 13-15, 2022 Fundamentals of Random Vibration and Shock Testing. Longmont, CO. This three-day Training in Fundamentals of Random Vibration and Shock Testing covers all the information required to plan, perform, and interpret the results of all types of dynamic testing. Some of the additional areas covered are fixture design, field data measurement and interpretation, evolution of test standards and HALT/HASS processes. https://equipment-reliability.com/open-courses/

SEMINARS & WEBINARS: Volume

May 9-13, 2022 Volume Metrology Seminar. Gaithersburg, MD. NIST. The 5-day OWM Volume Metrology Seminar is designed to enable metrologists to apply fundamental measurement concepts to volume calibrations. A large percentage of time is spent on hands-on measurements, applying procedures and equations discussed in the classroom. https://www.nist.gov/pml/weights-and-measures/calendar-events

SEMINARS & WEBINARS: Weight

Sep 8, 2022 Calibration of Weights and Balances. Lindfield NSW, Australia. National Measurement Institute (NMI), Australia. This course covers the theory and practice of the calibration of weights and balances. It incorporates hands-on practical exercises to demonstrate adjustment features and the effects of static, magnetism, vibration and draughts on balance performance. https://shop.measurement.gov.au/collections/physical-metrology-training

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

Parliament Backs Metrology Partnership Within Horizon Europe

European Parliament News, November 11, 2021 — The scheme, informally agreed with Council of Ministers, aims to develop, by 2030, new research capabilities for achieving the twin ecological and digital transitions.

The partnership on metrology - the science of measurement - also aims to support sales of new innovative products and services through the use and adoption of new metrology capabilities in emerging technologies and to contribute to the design and implementation of specific standards by 2030.

The Partnership aims to accelerate Europe's global leadership in metrology research by establishing autonomous European metrology networks to support and stimulate new innovative products, address societal challenges and enable the effective design and implementation of regulations and standards that underpin public policies.

During negotiations with Council, MEP insisted to make it clear that the States participating in the European Partnership must respect academic freedom, in particular the freedom to undertake scientific research, and promote the highest standards of scientific integrity. MEPs also want metrology activities to benefit all fields of knowledge and pushed for more openness and transparency in this field. The agreement with Council negotiated by rapporteur Maria Graça Carvalho (EPP, PT) was adopted with 536 votes to 5 and 4 abstentions on Thursday. It now needs formal approval by Council to enter into force.

"Metrology is an essential tool at the service of every field of knowledge. It plays a primary role in the development of technologies such as wind turbines or quantum computers and applications" said Ms Carvalho.

"It has been of key importance to the development and testing of ventilators and to the accuracy of common swab tests during the fight against COVID-19. In industry, it is the technology behind the assurance of quality in the manufacturing process, especially when it comes to producing sophisticated equipment in series. It is also vital to study the Earth and climate dynamics. We would not be where we are technologically without metrology, nor would we get where we want to go" she said.

"This new public-to-public partnership funded by Horizon Europe builds on the successes of previous European initiatives (EMRP and EMPIR), but it raises the stakes as we need to meet new policy objectives. Among the main points we were able to adopt I remind the importance of scientific excellence and academic freedom, the need to increase the scientific expertise and the value of scientific advice in the governance and decision-making mechanisms of the partnership. Furthermore, we managed to create more opportunities for synergies with other partnerships and other EU funding instruments, the introduction of more openness and transparency measures in its management practices and activities and the possibility to extend participation to a wider community of stakeholders, from industry to SMEs, but also academic institutions and research centres" she added.

Background

The proposal on the partnership follows the adoption of the Horizon Europe Programme. The proposed new metrology partnership builds on the existing European metrology research programme and the European metrology programme on innovation and research. It aims to tackle the challenges of the green and digital transition, and to help build an economy that works for the people.

Source: *https://www.europarl.europa.eu/news/en/press-room/20211108IPR16848/parliament-backs-metrology-partnership-within-horizon-europe*

UCF Develops the World's First Optical Oscilloscope

By Zenaida Gonzalez Kotala

December 13, 2021 — A team from UCF [University of Central Florida] has developed the world's first optical oscilloscope, an instrument that is able to measure the electric field of light. The device converts light oscillations into electrical signals, much like hospital monitors convert a patient's heartbeat into electrical oscillation.

Until now, reading the electric field of light has been a challenge because of the high speeds at which light waves oscillates. The most advanced techniques, which power our phone and internet communications, can currently clock electric fields at up to gigahertz frequencies — covering the radio frequency and microwave regions of the electromagnetic spectrum. Light waves oscillate at much higher rates, allowing a higher density of information to be transmitted. However, the current tools for measuring light fields could resolve only an average signal associated with a 'pulse' of light, and not the peaks and valleys within the pulse. Measuring those peaks and valleys within a single pulse is important because it is in that space that information can be packed and delivered.

"Fiber optic communications have taken advantage of light to make things faster, but we are still functionally limited by the speed of the oscilloscope," says Physics Associate Professor Michael Chini, who worked on the research at UCF. "Our optical oscilloscope may be able to increase that speed by a factor of about 10,000."

The team's findings are published in this week's Nature Photonics journal.

The team developed the device and demonstrated its capability for real-time measurement of the electric fields of individual laser pulses in Chini's lab at UCF. The next step for the team is to see how far they can push the speed limits of the technique.

The lead author of the paper is UCF postdoctoral scholar Yangyang Liu. Other authors include physics alums Jonathan Nesper '19 '21MS, who earned his bachelor's in math and master's in physics; Shima Gholam-Mirzaei '18MS '20PhD; and John E. Beetar '15 '17MS '20PhD.

Gholam-Mirzaei is now a postdoctoral researcher at the Joint Attosecond Science Laboratory at the National Research Council of Canada and University of Ottawa and Beetar is completing a postdoc at the University of California at Berkeley.

Chini had the idea for the single-shot waveform measurement scheme and oversaw the research team. Liu led the experimental effort and performed most of the measurements and simulations. Beetar assisted with the measurements of the carrier-envelope phase dependence. Nesper and Gholam-Mirzaei assisted with the construction of the experimental setup and with the data collection. All authors contributed to the data analysis and wrote the journal article.

Source: *https://www.ucf.edu/news/ucf-develops-the-worlds-first-optical-oscilloscope/*

Physics Associate Professor Michael Chini is part of the UCF team that created the world's first optical oscilloscope. Credit: University of Central Florida

Sneezes, Rain Clouds and Ink Jets: NIST Improves the Ability of Optical Microscopes to Measure the Volume of Microdroplets

NIST News, December 20, 2021 — Sneezes, rain clouds, and ink jet printers: They all produce or contain liquid droplets so tiny it would take several billion of them to fill a liter bottle.

Measuring the volume, motion and contents of microscopic droplets is important for studying how airborne viruses spread (including those that cause COVID-19), how clouds reflect sunlight to cool the Earth, how ink jet printers create finely detailed patterns, and even how a soda bottle fragments into nanoscale plastic particles that pollute the oceans.

By improving the calibration of a conventional optical microscope, researchers at the National Institute of Standards and Technology (NIST) have for the first time measured the volume of individual droplets smaller than 100 trillionths of a liter with an uncertainty of less than 1%. That is a tenfold improvement over previous measurements.

Because optical microscopes can directly image the positions and dimensions of small objects, their measurements can be used to determine the volume — proportional to the diameter cubed — of spherical microdroplets. However, the accuracy of optical microscopy is limited by many factors, such as how well the image analysis can locate the boundary between the edge of a droplet and the surrounding space.

To improve the accuracy of optical microscopes, NIST researchers developed new standards and calibrations for the instruments. They also devised a system in which they could simultaneously measure the volume of microdroplets in flight using microscopy and an independent technique, known as gravimetry.

Gravimetry measures volume by weighing the total mass of many microdroplets that accumulate in a container. If the number of droplets is controlled and the density — mass per unit volume — is measured, then the total mass registered on a scale can be used to calculate the average volume of one droplet. Although this is valuable information, because droplets can vary in size, imaging single droplets by optical microscopy enables a more direct and complete measurement.

Nonetheless, weighing the contents of a container is a tried-and-true method, and gravimetric measurements are readily linked to the International System of Units (SI) with high confidence. Such measurements are the most reliable because the units are based on fundamental constants of nature, which do not change over time. Therefore, the team used gravimetry to check the reliability of microscopy in determining droplet dimensions.

To improve the accuracy of locating the microdroplet edges, the researchers tested two standard objects to mimic a microdroplet and calibrate the image boundaries. For each standard object, a precisely and accurately measured distance between its edges allows calibration of the corresponding image boundaries.

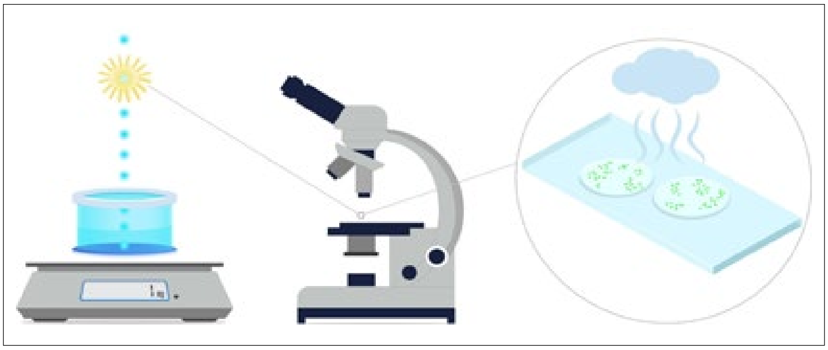
The first standard object consisted of sharp metal edges separated by a calibrated distance to represent the diameter of a microdroplet. Such "knife edges," which assume a flat boundary between the edge of a microdroplet and surrounding space, are commonly used to test optical systems but bear only a passing resemblance to microdroplets.

The other standard object consisted of plastic spheres with calibrated diameters, which produce images in the microscope very similar to those of microdroplets. Indeed, the scientists found that when they used the plastic spheres to calibrate their measurements of image boundaries, the microdroplet volume derived from microscopy precisely matched that from gravimetry. (The researchers found that the knife edges resulted in a poorer match.) The scientists also calibrated several other aspects of the optical microscope, including focus and distortion, maintaining the links to the SI throughout.

With these improvements, optical microscopy resolved the volume of microdroplets to one trillionth of a liter. The standards and calibrations are practical and can be applied to many types of optical microscopes employed in basic and applied research, the researchers noted. In fact, the less advanced the microscope optics, the more a microscopy measurement can benefit from standards and calibrations to improve the accuracy of image analysis.

The NIST researchers, in collaboration with the University of Maryland in College Park, reported the findings December 20 online in *Analytical Chemistry*.*

In their main experiment, the researchers used a printer to shoot a jet of microdroplets of cyclopentanol, a viscous alcohol that evaporates slowly. They precisely controlled the jet to produce a known number of microdroplets. As the jet of microdroplets flew from the printer



Gravimetry, microscopy, and deposition of microdroplets. Credit: K. Dill/NIST into a container a few centimeters away, they were backlit and imaged with the optical microscope. The researchers then weighed the container and its accumulation of many microdroplets.

With the optical microscope calibrated and checked by comparing it with the gravimetry method, the team embarked on another experiment, replacing the cyclopentanol with water microdroplets containing nanoparticles of polystyrene, which are common but unofficial standards for nanoplastic analysis. This system more closely resembles the type of sample that many scientists are interested in, for instance in studying plastic pollution. The researchers used the printer to deposit rows of individual water microdroplets on a surface one at a time.

After landing on the surface, the water microdroplets evaporated, leaving behind the nanoparticles. The team then counted the nanoparticles, which were labeled with a fluorescent dye. In this way, the team recorded the number of particles suspended within the volume of each microdroplet, which provides a measure of concentration. This measurement is both a way to sample the bulk liquid and study the properties of microdroplets containing small numbers of nanoparticles.

Using this method and an illumination system that is faster than the one employed by the team, scientists would have the capability of measuring the volume, motion and contents of a spray or cloud of microdroplets, the researchers said. Such measurements could play a key role in future studies for epidemiological, environmental and industrial applications.

*Paper: Lindsay C.C. Elliott, Adam L. Pintar, Craig R. Copeland, Thomas B. Renegar, Ronald G. Dixson, B. Robert Ilic, R. Michael Verkouteren and Samuel M. Stavis. Sub-picoliter Traceability of Microdroplet Gravimetry and Microscopy. Analytical Chemistry. Published online Dec. 20, 2021. DOI: 10.1021/acs.analchem.1c02640

Source: *https://www.nist.gov/news-events/news/2021/12/sneezes-rain-clouds-and-ink-jets-nist-improves-ability-optical-microscopes*

International Collaboration Sets New Record for Comparison of Distant Ultrastable Lasers Through an Optical Fiber Network

NPL News, 11 Jan 2022 — Led by NPL, an international consortium has set a new record for comparing distant ultrastable lasers through a metrological optical fiber network.

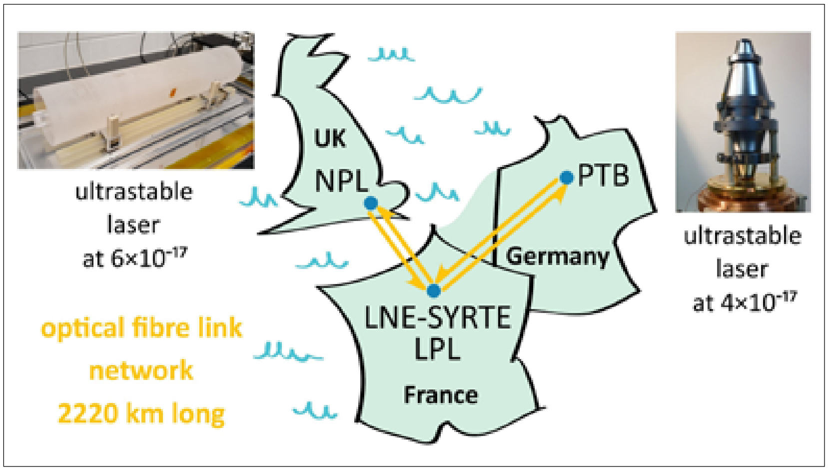
Using cutting-edge optical frequency standards developed at PTB and NPL, the team has been able to demonstrate that their measurement precision is preserved even when transmitted across thousands of kilometers of optical fiber.

This network has been specifically set up for comparing optical atomic clocks, the next generation of atomic clocks which is expected to improve our ability to measure time and frequency by several orders of magnitude. The extreme precision of optical atomic clocks will enable new applications, such as using the change of rate of a clock to measure gravity —an effect described by Einstein's theory of general relativity. Other applications include improvement in communication, synchronisation and localization.

The metrological optical fiber network utilized in the measurements is operated by multiple research institutes, as a result this activity has been highly collaborative and international, involving 32 authors from five institutions, namely: NPL in the UK, RENATER, LPL and LNE-SYRTE in France and PTB in Germany.

Just like quartz oscillators are key components in conventional microwave clocks, ultrastable lasers play a critical role in optical clocks. State-of-the art ultrastable lasers like the ones used in this study achieve a stability better than 6 parts in 100,000,000,000,000,000. For instance, fractionally this is equivalent to a wobble of the distance between the Earth and the Sun of less than the width of a hair. Such precision is realized using optical reference cavities providing an optical standing wave with a frequency stability set by the distance of the mirrors. The stability of the optical references demonstrated in this work corresponds to an average variation of the position of the mirrors 50 times smaller than the diameter of a proton, over a cavity length of about half a meter.

Being able to transfer such precision to distant locations not only proves once again that optical fiber networks can be used to compare optical atomic clocks, it also enables more widespread, efficient utilization of the cutting-edge research infrastructure otherwise only available at a few national laboratories. In this work we discuss how this measurement precision can be made available



Schematic layout of the experiment for comparing two ultrastable lasers through a 2220 km long metrological optical fibre link network.

through optical fiber to a much larger community of users, ranging from other national laboratories, academia and industry.

This work is available at: M. Schioppo et al. "Comparing ultrastable lasers at 7 × 10−17 fractional frequency instability through a 2220 km optical fibre network," *Nature Communications* (2022), https://doi.org/10.1038/s41467-021-27884-3.

Marco Schioppo, Senior Research Scientist, NPL states: "This work is important as it demonstrates that it is possible to compare two geographically distant ultrastable lasers and measure their fundamental noise using an optical fiber network. We show that ultrastable lasers can be used to effectively measure the total fiber link noise. We also assess the possibility to disseminate ultrastable light to distant users through optical fiber. Our work is an important step towards making available the time and frequency high-precision measurement capability of a national metrological institute to a wide range of users."

Jochen Kronjäger, Senior Research Scientist, NPL states: "I find it absolutely fascinating to see how two world-leading ultrastable lasers, developed independently and both pushing the boundaries of optical technology, can be compared to reveal their fundamental noise, despite being separated geographically by almost 800 km. It's a fantastic demonstration of the power of light, made possible by many years of international collaboration."

Corresponding authors:
Marco Schioppo marco.schioppo@npl.co.uk
Jochen Kronjäger jochen.kronjaeger@npl.co.uk

Source: *https://www.npl.co.uk/news/record-comparison-of-distant-ultrastable-lasers*

CAL-TOONS by Ted Green teddytoons@icloud.com

17 - 20 May 2022
PARIS

11th International Gas Analysis Symposium & Exhibition

PRESS RELEASE - 22 February 2022

GAS ANALYSIS 2022:
A GREEN INDUSTRIE FIGUREHEAD

GAS Analysis Symposium & Exhibition is the world symposium for gas analysis, gathering more than 300 participants and highly valuable for the gas analysis community. The event will thrive under the aegis of the CFM in **Paris Nord Villepinte** during its 11th edition from **17** to **20 May 2022**.

A rich programme combining Hydrogen, Biogas, Energy and Environment

Responding to global challenges, GAS Analysis has positioned itself as the best forum for discussing the latest cutting-edge advances and applications in the industry. It **attracts many key players in the sector**: experts, policy makers, technical managers, research laboratories, manufacturers and end-users.

It will be run under 2 key application axes: Environment and Energies. Its programme will consist of 80 lecture and poster presentations dealing with the latest advances in **gas metrology**, **hydrogen**, **decarbonation**, **energy transition**, **industrial innovation**, **climate and air quality**. Also on the menu: 4 short courses as well as an exhibition area animated by **face-to-face meetings**.

A GAS Analysis hub within an expanded exhibition

GAS Analysis is in partnership with **Global Industrie/Measurement World**. The symposium is claimed as a pillar of an industry in the desire for change: in the midst of the fight against global warming and faced with the integration of the environmental factor in our production methods, this unprecedented conjunction then takes on its full meaning!

In order to ensure optimal cohesion, the exhibition part of GAS Analysis will be the meeting point of the symposium participants, benefiting from a central position. The heart of this exhibition named "**GAS Analysis Hub**" will be lively through **poster sessions** as well as **non-stop catering service**, aligned with the symposium programme.

Placed in a privileged way around this hub, the GAS2022 exhibitors will be able to be in direct contact with the participants of the symposium and other organisations of the **Instrumentation**, **Metrology** and **Analysis** sector.

GAS Analysis is organised by Air Liquide, Analytical Controls by Pac, Cetiat, Effectech, Euramet, LNE, Linde, NPL, VSL, Shell Global Solutions International and the Collège Français de Métrologie.

Sponsors declared to date: Agilent Technlogies et Orthodyne

Exhibitors confirmed to date: Agilent Technologies, Alytech, AP2E, APIX Analytics, Bohr / Endet, Bundesanstalt für Materialforschung und -prüfung (BAM) / MefHySto, Chemlys, EffecTech, Endress+Hauser, Etalonair, LNI Swissgas, Meeco, mirSense, National Physical Laboratory (NPL), Orthodyne, Picarro, Process Insights, PST Process Sensing Technologies, SIAD, Soclema, Thermo Fisher Scientific...

The detailed programme is now available, see you there!

Organiser and Press Contact: Collège Français de Métrologie
+33 (0)4 67 06 20 36 - gas2022@cfmetrologie.com - www.gasanalysisevent.com

Overview of the ISO/IEC 17025 Revision Process

Diana Baldi and Heather A. Wade

ISO standards are considered the top of the global standards hierarchy. This means that ISO standards supersede regional or national standards, where an equivalent ISO standard exists. All international standards managed by ISO are developed based on a market need within a specific subject area. If a proposed need is accepted by ISO, the project proposal proceeds through the ISO standards development process. ISO standards are developed on a consensus-based approach and take into account comments from all stakeholders. Once published, all ISO standards are reviewed at least every five years to determine if a revision is required. The systematic review process ensures that ISO International Standards and other deliverables remain up-to-date and globally relevant [1]. ISO/IEC 17025 is one of these international standards that has undergone a series of updates over the past 30+ years. We will explore the revision process and history for ISO/IEC 17025 as well as the international organizations who play a part in its application and support.

What Is ISO/IEC 17025?

ISO/IEC 17025 is an international standard that specifies the requirements for a laboratory management system. The standard contains a set of requirements enabling laboratories to improve their ability to produce consistently valid results. It applies to both testing laboratories and calibration laboratories.

Why Has ISO/IEC 17025 Been Revised?

Various management system practices have come into use worldwide over the last thirty-plus years. All ISO standards are scheduled for review at least every five years to establish if a revision is required to keep them current and relevant for the marketplace. Organizations that use multiple management systems standards are increasingly demanding a common format and language that is aligned between those standards. ISO/IEC 17025:2017 responds to the latest trends for laboratories and to be more compatible with other standards related to conformity assessment (i.e., ISO/IEC 17000 series of standards).

What Is the General Transition Period for Accreditation?

The laboratories worldwide have a period of three years from the date of publication to transition to the new version. The impact of this revision will be greater than the 2005 edition. Eighteen months from the date of publication, any new accredited certifications issued will be to ISO/IEC 17025:2017. Originally, as of November 2020, ISO/IEC 17025:2005 would have been completely withdrawn and all labs with ISO/IEC 17025 accreditation will need to be accredited to ISO/IEC 17025:2017. However, due to the COVID-19 pandemic, ILAC Resolution GA 20.15 (November 2016) passed an ILAC ballot thus extending the transition period for ISO/IEC 17025:2017 from 30 November 2020 to 1 June 2021: "This extension has been granted to ensure all accreditation bodies and the accredited laboratories are able to achieve the remaining transitions in a robust manner under the restrictions imposed as a result of the global coronavirus disease 2019 (COVID-19) outbreak [2]."

Where Are We in the Revision Process?

The ISO/IEC 17025:2017 standard was published November 2017. On the right is a timeline of ISO 9001 and ISO/IEC 17025 revision history. ISO 9001 is included as it has been a supplemental source for management system practices and requirements used in conjunction with ISO/IEC 17025.

Year	Standard
1987	ISO 9001:1987 (first edition)
1990	ISO/IEC Guide 25
1994	ISO 9001:1994 (first minor revision)
1999	ISO/IEC 17025:1999 (renumbered Guide 25)
2000	ISO 9001:2000 (first major revision)
2005	ISO/IEC 17025:2005
2008	ISO 9001:2008 (second minor revision)
2010	ILAC/SABS requested CASCO workgroup to revise ISO/IEC 17025
2015	ISO 9001:2015 (second major revision)
2017	ISO/IEC 17025:2017
Nov 2020	ISO/IEC 17025:2005 original withdrawal date
June 2021	ISO/IEC 17025:2005 extension withdrawal date (due to COVID-19)

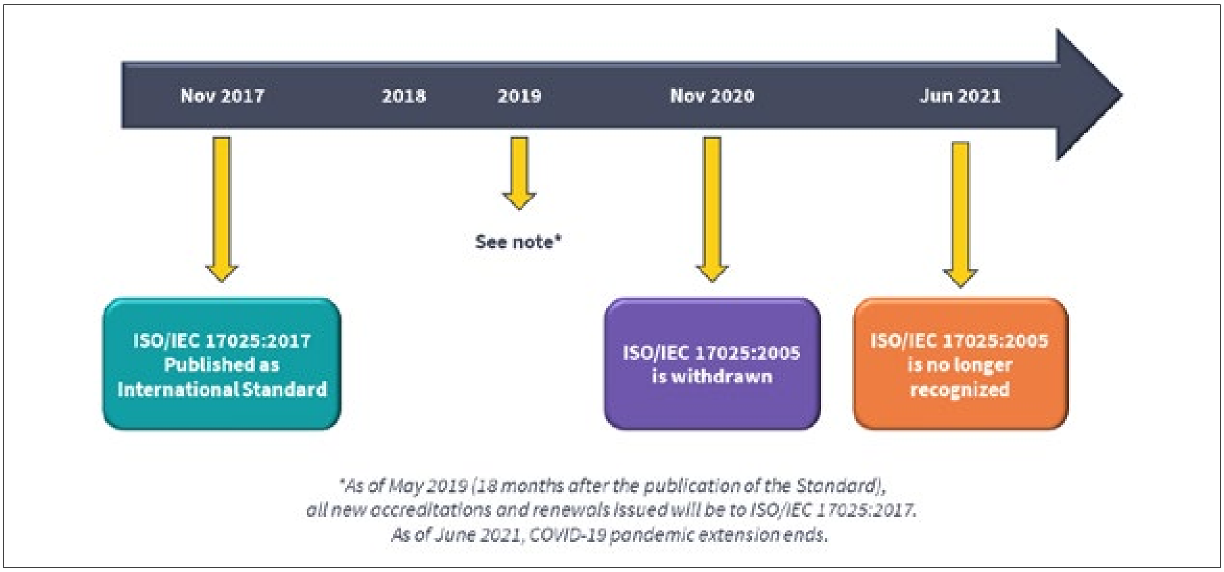


Figure 1. General Transition Period for Accreditation

Since the end of the transition period extension, the accreditation of a laboratory to ISO/IEC 17025:2005 is no longer recognized under the ILAC Arrangement.

Can Accreditation Bodies Define a Different Transition Period?

Yes. For example, for a while, Standards Council of Canada had noted that they may allow laboratories to continue to be assessed to the 2005 version under extenuating circumstances. Examples of valid, extenuating circumstances include, but were not limited to, the following: Corporate/Group accreditation laboratories that are working on a consolidated approach to implementing the revised standard, or laboratories that hold two or more accreditations from different accreditation bodies, who are required to meet different transition and implementation plans developed by the accreditation bodies.

Who's Who on the International Stage?

The four international bodies responsible for metrology, accreditation, and standardization worldwide are the following:

1. **BIPM = The International Bureau of Weights and Measures (https://www.BIPM.org)**
   a. BIPM is the coordinator of the world-wide measurement system.
   b. BIPM provides a forum for Member States to act together on matters related to measurement science and measurement standards.
   c. BIPM publishes the SI Brochure, which defines the International System of Units (SI).
2. **OIML = The International Organization of Legal Metrology (https://www.OIML.org).** Legal metrology is the application of legal requirements to measurements and measuring instruments. Legal metrology encompasses, in part, how items are measured for sale and trade. OIML is an intergovernmental treaty organization which:
   a. Develops model regulations, standards, and related documented use develops model regulations, standards, and related documents for use by legal metrology authorities and industry;
   b. provides mutual recognition systems which reduce trade barriers and costs in a global market;
   c. represents the interests of the legal metrology community within international organizations and forums concerned with metrology, standardization, testing, certification, and accreditation;
   d. promotes and facilitates the exchange of knowledge and competencies within the legal metrology community worldwide; and
   e. cooperates with other metrology bodies to raise awareness of the contribution that a sound legal metrology infrastructure can make to a modern economy.

3. **ILAC = The International Laboratory Accreditation Cooperation (https://ILAC.org)**
   a. "ILAC is the international authority on laboratory, inspection body, reference material producer and proficiency testing provider accreditation, collectively known as conformity assessment bodies (CABs), with a membership consisting of accreditation bodies and stakeholder organizations throughout the world."
   b. The International Laboratory Accreditation Cooperation (ILAC) is the international organization for accreditation bodies operating in accordance with ISO/IEC 17011 and involved in the accreditation of conformity assessment bodies including calibration laboratories (using ISO/IEC 17025), testing laboratories (using ISO/IEC 17025), medical testing laboratories (using ISO 15189) and inspection bodies (using ISO/IEC 17020).
4. **ISO = The International Organization for Standardization (https://www.ISO.org)**
   a. ISO is an "independent, non-governmental international organization with a membership of 164 national standards bodies" that, through its members, "brings together experts to share knowledge and develop voluntary, consensus-based, market relevant International Standards that support innovation and provide solutions to global challenges."
   a. The Council Committee on Conformity Assessment (CASCO) is the ISO committee that works on issues related to conformity assessment.

What Do These Four Organizations Do?

In November 2018, these four organizations issued a Joint Declaration on Metrological Traceability emphasizing that "Metrological traceability is one of the elements that establishes international confidence in the worldwide equivalence of measurements [3]."

These four bodies collaborate, with other international stakeholders, in the Joint Committee for Guides in Metrology, (JCGM), responsible for developing common documents. Two JCGM documents key to this Declaration are:

1. **Uncertainty in Measurement - Part 3 - Guide to the Expression of Uncertainty in Measurement (GUM) – JCGM 100.** Two related documents are OIML G 1-100 and ISO/IEC Guide 98-3. All three documents promote a consistent and common approach to the evaluation of measurement uncertainty in a variety of metrological situations; and
2. **International vocabulary of metrology - Basic and general concepts and associated terms (VIM) – JCGM 200.** Two related documents are OIML V 2-200 and ISO/IEC Guide 99.

The latest versions of these and related publications can be downloaded free of charge from the BIPM website.

Who Publishes ISO/IEC 17025:2017?

ISO/IEC 17025:2017 is published by ISO (International Standards Organization) and IEC (International Electrotechnical Commission). IEC is one of the three global sister organizations (IEC, ISO, and ITU) that develop International Standards for the world.

IEC is the world's leading organization for the preparation and publication of International Standards for all electrical, electronic, and related technologies.

ISO is an "independent, non-governmental international organization with a membership of 164 national standards bodies" that through its members, "brings together experts to share knowledge and develop voluntary, consensus-based, market relevant International Standards that support innovation and provide solutions to global challenges."

Who Oversees Accreditation to ISO/IEC 17025:2017?

ILAC maintains a formal list of signatories on their Mutual Recognition Agreement (MRA). The accreditation bodies that are signatories to the ILAC MRA have been peer evaluated in accordance with the requirements of ISO/IEC 17011 to demonstrate their competence. The ILAC MRA signatories agree to accept the results of each other's accredited Conformity Assessment Bodies under the ILAC MRA. Hence, the results from the Conformity Assessment Bodies accredited by the ILAC MRA signatories are able to be recognized internationally. The aim being, "Accredited Once, Accepted Everywhere [4]."

BEWARE OF UNRELIABLE MARKS. Here are two examples of UNRELIABLE seals that imply ISO/IEC 17025 "approval."

Be sure to understand the difference between *certification* and *accreditation*. Accreditation is the proper term to use. Confirm the authorizing authority (the accreditation body) on any ISO/IEC 17025-accredited testing or calibration certificates you use is listed on ILAC's Mutual Recognition Agreement list: https://ilac.org/signatory-search/.

Who Works Along with ILAC in the Realm of Accreditation?

The International Accreditation Forum (IAF) is the world association of Conformity Assessment Accreditation Bodies and other bodies interested in conformity assessment in the fields of management systems, products, services, personnel and other similar programs of conformity assessment. Its primary function is to develop a single worldwide program of conformity assessment which reduces risk for business and its customers by assuring them that accredited certificates may be relied upon. Accreditation assures users of the competence and impartiality of the body accredited. [5]

In short, IAF ensures that "its accreditation body members only accredit bodies that are competent to do the work they undertake and are not subject to conflicts of interest." Another way to express this is that IAF ensures accreditation bodies are competent and impartial.

What is the Scope of Accreditations Worldwide?

- Over 94,000 accredited conformity assessment bodies (CABs)
- Over 103 economies represented

Conclusion

ISO/IEC 17025 is the top internationally recognized standard providing the requirements and expectations for testing and calibration laboratories. Whether the use of ISO/IEC 17025 is required or voluntary, the coordination between multiple, high-level global non-governmental organizations provides for uniform application of ISO/IEC 17025. This standardized and consensus-based solution ensures that each member economy has a voice in the standards development and application. As a result, global trade and consumer protection are enhanced and supported.

This article contains an overview of the ISO/IEC 17025 revision process and is an excerpt of Chapter 1 from ISO/IEC 17025:2017 Requirements Overview e-book by Diana Baldi and Heather A Wade. Download the entire ebook to gain an overview of the requirements within ISO/IEC 17025:2017. The ebook is written in practical language to help demystify these requirements. Available for free - Download from: https://bit.ly/Free-17025-ebook or https://bit.ly/17025-ebook

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[1] https://www.iso.org/developing-standards.html
[2] https://ilac.org/latest_ilac_news/transition-period-for-iso-iec-17025-extended/
[3] https://www.bipm.org/documents/20126/42177518/BIPM-OIML-ILAC-ISO_joint_declaration_2018.pdf/7f1a4834-da36-b012-2a81-fc51a79b0726
[4] https://ILAC.org
[5] https://www.iaf.nu.

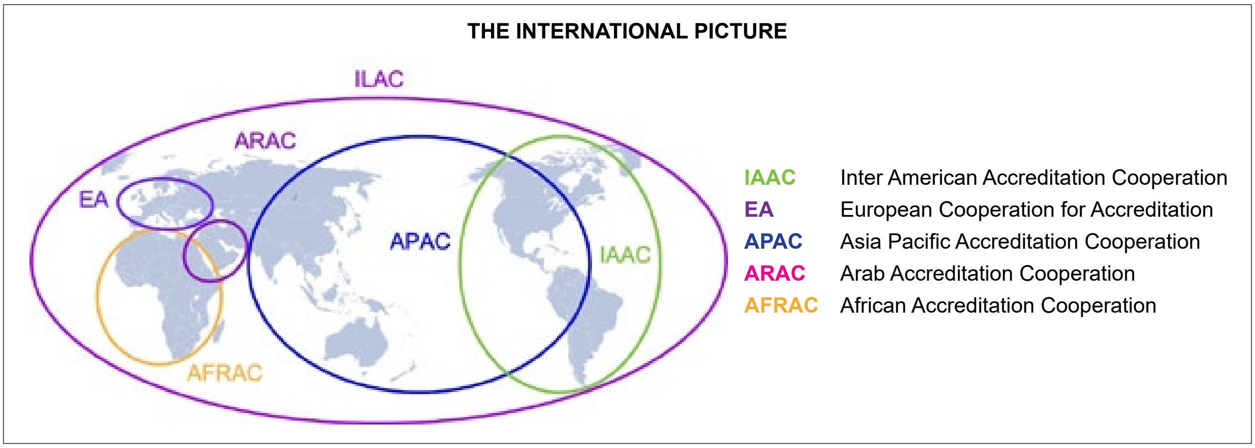

Figure 2. ILAC Regional Cooperation Bodies. Image provided by ILAC with permission.

ENOB: The Best Digitizer Performance Metric

By Andrew Dawson, Ph.D.
Vitrek

Introduction

While the nominal vertical resolution of a high-speed waveform digitizer (specified in bits) is often promoted, its true performance is provided by its measured Dynamic Parameters and in particular by its *Effective Number of Bits (ENOB)*. This article describes measurement of the Dynamic Parameters and presents measurements for a leading-edge GaGe 12-bit Digitizer.

A widely used digitizer-like device, the Digital Storage Oscilloscope (DSO), is optimized for the visualization of unknown signals [1]. The relatively low 8-bit vertical resolution of most DSOs is sufficient for signal visualization and is offered at the highest sampling rates (~200 GigaSamples/second). Furthermore, high-end DSOs are often optimized for the determination of signal edge positions in the time-domain, such as in eye-diagram measurements. Accordingly, product marketing typically promotes DSO's high input bandwidth and vertical performance parameters are not emphasized.

Signal Fidelity Considerations

In contrast to DSOs, dedicated digitizers—such as those on modular platforms like PCIe or PXIe—are usually optimized for the rapid acquisition and analysis of small changes in familiar signals. While providing lower maximum sampling rates, digitizers typically offer higher vertical resolutions of 12-, 14-, and 16-bits. Consequently, a proper understanding of the Dynamic Parameters is paramount for digitizer users.

There is an important distinction between the *absolute accuracy* and the *relative accuracy* of a digitizer. The absolute accuracy of a digitizer describes how close its measured voltage values correspond to true absolute voltage reference standards. By contrast, its relative accuracy specifies the fidelity of the shape of the acquired waveform with no reference to absolute voltage standards. Using on-board calibration techniques, a high-speed digitizer may achieve absolute accuracies of order 0.1% of the full-scale input voltage range. In most digitizer applications, however, users are concerned principally with relative accuracy, which is specified by the Dynamic Parameters.

The fidelity of a signal acquired by a digitizer device may be compromised by three distinct factors:

1. Addition of random noise by the digitizer to the acquired signal.
2. Distortion of the acquired signal by the digitizer.
3. Irregularities in uniformity of the time intervals between samples acquired by the digitizer arising from imperfections in the ADC clocking signal.

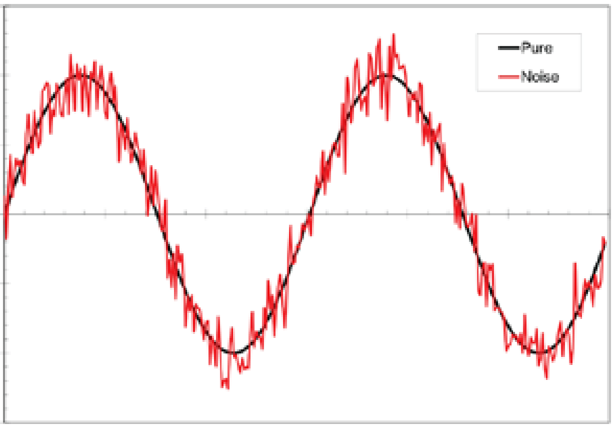

Figure 1a. Illustration of a pure sine wave (black) and one that has picked up noise (red).

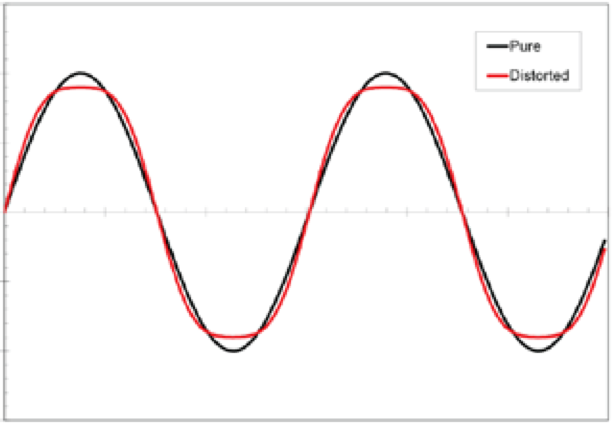

Figure 1b. Illustration of a pure sine wave (black) and one that has suffered distortion (red).

The distinction between signal noise and signal distortion is illustrated in Figures 1a and 1b. The figures show a pure sine wave, together with a sine wave that has been compromised by the addition of broadband signal noise and by signal distortion. Distortion is shown as attenuation near the input range limits, which is the typical precursor to signal clipping.

As a rule, the design of an amplifier for low noise and for minimal distortion represents opposing design goals. This principal is illustrated in Figure 2, which shows the transfer curve for an idealized amplifier component. Consider that a small amount of random noise is picked up at the output of this amplifier. If the amplifier was configured for high gain, then it operates in the red region of Figure 2. In this case, the signal suffers high signal distortion, due to the visible curvature of the transfer curve at higher voltage where it begins to saturate. Alternately, if the amplifier was configured for low gain in the green region of Figure 2, then the transfer curve is highly linear and distortion is minimal. The reduced output signal amplitude, however, will result in the noise pickup having a proportionately larger effect. This simple example illustrates the interdependencies that links noise and distortion—namely that if one increases the other generally decreases.

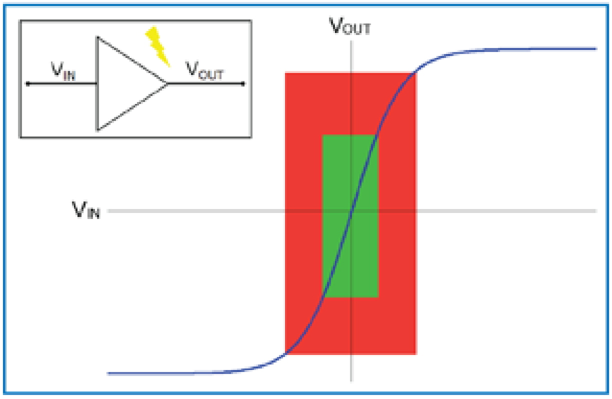

Figure 2. Transfer function of an idealized amplifier. Small signal (green) and large signal (red) regions are indicated.

The effects upon signal fidelity of imperfections in the ADC clocking signal are more difficult to describe. In general, we may distinguish two types of imperfections. In the case of *Phase Jitter*, the clock signal edges vary about their correct positions that are spaced exactly uniformly by the fixed clock period. In the case of *Frequency Drift*, however, the actual instantaneous clocking frequency changes over time. Phase Jitter tends to be a greater concern over the shorter term while Frequency Drift error builds up over the longer term. The effect of clocking imperfections will not be directly considered in the measurements below and their effects are assumed to manifest as an associated degradation in measured noise and/or distortion.

Dynamic Parameter Measurement

There are two different measurement methods for characterizing digitizer performance. One method is performed in the time domain and the other in the *frequency domain* [2]. Both methods involve acquisition of a high-purity sine wave signal by the digitizer under test. Creation of this high-purity sine wave usually requires filtering of the signal generator output by a high-quality, multi-pole passive band-pass filter to remove noise and distortion intrinsic to the signal.

In the time-domain method, which is specified in IEEE 1057-1994, a sine wave function is fitted to the sine wave signal acquired by a digitizer. The resultant error function is then normalized to obtain the *SINAD*. From the *SINAD*, the *ENOB* is calculated as:

$$ENOB = \frac{SINAD - 20\log_{10}\sqrt{3/2}}{20\log_{10} 2} \approx \frac{SINAD - 1.76\text{ dB}}{6.02}$$

The *ENOB* is the single most important overall indicator of digitizer performance and allows for direct comparison with the number of bits indicated by the digitizer 's nominal resolution. The *ENOB* depends upon signal frequency and also changes with all adjustable digitizer input settings —notably its input range. The main advantage of the time-domain method is that it produces *ENOB* values with no adjustable parameters. The primary disadvantage is that it does not allow for clear separation and characterization of digitizer noise and distortion.

The second method of characterizing digitizer performance requires signal analysis in the frequency domain. The acquired high purity sine wave is subjected to Fourier analysis and a Power Spectrum is obtained (Figure 3), usually after application of a time-domain windowing function to reduce spectral leakage.

Once the Fourier spectrum has been obtained, three different types of frequency bins are identified:

1. *Fundamental Bins* are those within a specified range of the known input sine wave frequency f_0.
2. *Harmonic Bins* are those within a specified range of harmonic frequencies ($2f_0$, $3f_0$, $4f_0$...).
3. *Noise Bins* are all remaining frequency bins.

The sum of all power amplitude values within each of the three types of bins respectively provides the Fundamental *Power F*, the Harmonic *Power H*, and the Noise *Power N*. Unlike with the time-domain technique, the identification of these three power values allows calculation of three *Dynamic Parameters*:

Signal-to-Noise Ratio (SNR): $SNR \equiv 10\log_{10}\left(\frac{F}{N}\right)$

Total Harmonic Distortion (THD): $THD \equiv 10\log_{10}\left(\frac{H}{F}\right)$

Signal-to-Noise-and-Distortion Ratio (SINAD): $SINAD \equiv 10\log_{10}\left(\frac{F}{N+H}\right)$

Unlike in the time-domain, the frequency-domain technique requires the adjustment of spectral parameters, such as the windowing function type and the number of frequency bins used to determine *F*, *N* and *H*. However, the method has the clear advantage of separating the noise and distortion introduced by the digitizer, which are respectively quantified by the *SNR* and the *THD*. The spectral display used in the frequency-domain method also provides a useful visual tool for design feedback during digitizer development.

As in the time-domain technique, the *ENOB* is calculated directly from the *SINAD*. The two methods may be shown experimentally to render equivalent *ENOB* values in most circumstances.

Independent of any noise pick-up within the digitizer, the act of digitization intrinsically adds noise to the signal. This is because the digitizer transforms a continuous analog voltage value into a discrete integer value, which results in an associated truncation error. This truncation adds a small uniform power to all frequency bins in the spectrum that can usually be ignored.

Most uncorrelated "random" noise added to the input signal by a digitizer usually results from pick-up of unavoidable local digital signals. This pickup leads to a broad spectrum of noise across the frequency spectrum and contributes to the reduction of the SNR.

The digitizer 's *THD* is primarily degraded by signal distortion imposed within the digitizer 's front end signal-conditioning circuitry, as illustrated in Figure 2. Unlike distortion, noise pickup is generated within a digitizer independent of an input signal so that the SNR does not depend upon the input signal frequency. In sharp contrast, distortion requires the presence of a signal and usually increases markedly with its frequency due to increased amplifier distortion. As a result, the digitizer's *THD*, *SINAD* and *ENOB*, usually degrade markedly with increasing signal frequency.

The fact that distortion produces harmonic frequency peaks is easily illustrated by considering the simplest possible distortion scheme, which is modeled in the equation:

$$V_{MEASURED} = A \times V + B \times V^2$$

where V is the voltage input to the digitizer, $V_{MEASURED}$ is the voltage measured by the digitizer, and *A* and *B* are constants. The first term is linear and so causes no distortion while the second non-linear term can introduce distortion. Next, we insert a sinusoidal signal with frequency f_0 for the input V and use an elementary trigonometry identity:

$$V_{MEASURED} = A \times sin(2\pi f_0 t) + B \times sin^2(2\pi f_0 t)$$

$$V_{MEASURED} = A \times sin(2\pi f_0 t) + \tfrac{1}{2} B \times (1 - cos(4\pi f_0 t))$$

So, the effect of the second non-linear distortion term is to create a harmonic sine wave component at $2f_0$ — twice the input frequency. Real distortion is represented by a more complex distortion term, which leads to components at all harmonic frequencies $2f_0$, $3f_0$, $4f_0$... Generally, we consider harmonics up to $5f_0$.

Another useful digitizer performance parameter that may be extracted from a Fourier spectra like Figure 3

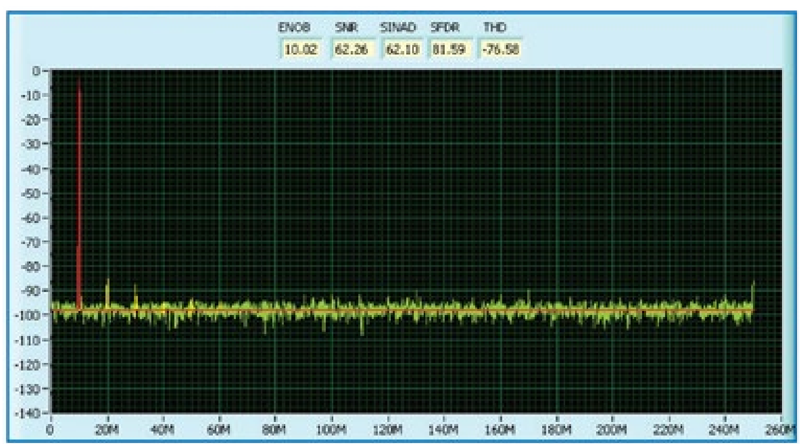

Figure 3. Fourier Power Spectrum used for calculating Dynamic Parameters for a 12-bit GaGe digitizer with a 10 MHz sine wave input signal and sampling at 500 MS/s. Fundamental, Harmonic and Noise frequency bins are respectively indicated in red, yellow and green.

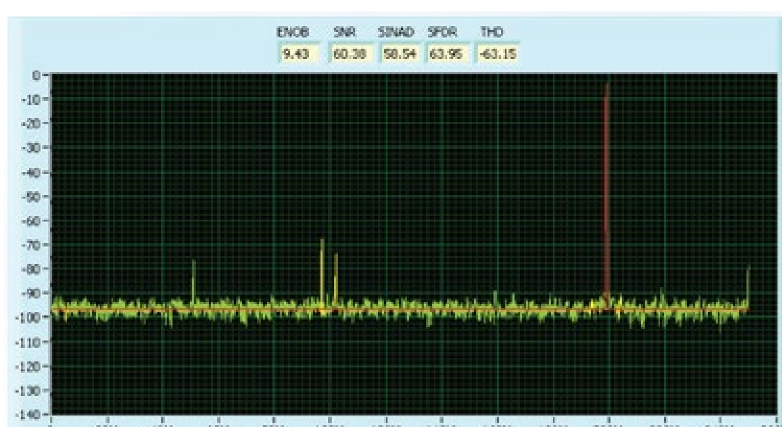

Figure 4. Fourier Power Spectrum like in Figure 3 but for a 199 MHz sine wave input signal.

is the Spurious Free Dynamic Range (SFDR). This aptly named parameter is the vertical measure from the top of the Fundamental frequency peak to the top of the highest non-Harmonic peak in the Fourier spectrum. Valuable in communications, the SFDR determines the effective detectability limit of weak narrowband communication signals.

Discussed above, clocking Phase Jitter leads to broad-band noise and a skirt-like swell around the Fundamental peak and so mostly affects the SNR, not the THD. Long term Frequency Drift on the clock leads to frequency and timing errors. Modern digitizers are equipped with a high-stability sampling oscillator disciplined by high-precision 10 MHz reference oscillators in order to minimize both Phase Jitter and Frequency Drift.

Dynamic Parameter Results

Having defined the Dynamic Parameters, we now present measurements on a high-performance 12-bit GaGe digitizer. From the definitions, we can conclude that the *ENOB* (and the *SINAD* from which it is trivially derived) is the single most informative digitizer performance parameter since it combines both digitizer noise and distortion into a single metric.

Like the noise and distortion, a digitizer's *ENOB* and input bandwidth are inversely related; if one improves then the other degrades. A simple illustration is the filtering of a signal by a low-pass filter. This action reduces high frequency noise and attenuates distortion harmonics, thus improving the *ENOB* while reducing the input bandwidth to the filter's roll-off frequency.

Both Figure 3 and Figure 4 show the Fourier signal spectrum from a GaGe 12-bit digitizer sampling at 500 MS/s with accompanying Dynamic Parameter Measurements. The two figures were produced with input signals frequencies of 10 MHz and 199 MHz, respectively.

The 10 MHz *ENOB* from Figure 3 is just over 10, which is not especially good for a 12-bit digitizer. The near equality of the *SNR* and *SINAD* (or equivalently, the much higher absolute value of the THD) show that the performance is principally limited by noise and that distortion is insignificant.

The impressive performance of the 12-bit digitizer is highlighted only in Figure 4, for which the signal frequency is 199 MHz. First, because of the high signal frequency, harmonics are aliased to lower frequencies. Specifically, they are reflected by the Nyquist frequency of 250 MHz (half the 500 MS/s sampling frequency). For example, the second harmonic at 2 × 199 MHz = 398 MHz is aliased to 500 MHz − 398 MHz = 102 MHz.

In contrast to Figure 3, Figure 4 shows that noise and distortion are significant contributors to *ENOB* since the *SNR* and *THD* have absolute values of the same order. The 9.43 ENOB is excellent for a signal frequency of almost 200 MHz. Taken together, Figures 3 and 4 illustrate how GaGe has sacrificed some *ENOB* performance at 10 MHz in order to achieve excellent performance at near 200 MHz. This achievement resulted from making design choices to minimize distortion at the expense of noise, which corresponds to choosing the green region over the red region in the simplified picture of Figure 2.

Dynamic Parameter measurements at several signal frequencies allow the digitizer user to understand the performance when using signals from their real-world application. Furthermore, such multiple measurements inhibit digitizer manufacturers from specifying parameters at strategic signal frequencies to maximize performance, for example by hiding spurious peaks under the fundamental.

Superior Dynamic Parameters are paramount in applications where the signal has a high dynamic range and so contains both high and low amplitude components. For example, a high SNR enables a low threshold for the detection of low-level time-domain pulse amplitudes, which routinely occur in the signals acquired in particle physics applications and in ultrasonics and other time-of-flight applications. Alternately, in frequency-domain application like communications and spectroscopy, a high SFDR and THD are required to minimize spurious spectral peaks. Consequently, manufacturers should provide the complete set of Dynamic Parameters (ENOB, SNR, THD, SINAD and SFDR) in the digitizer technical specifications.

Conclusion

We have presented the correct frequency-domain method of characterizing the signal fidelity of a digitizer device. Our discussion focused on the Dynamic Parameters *SNR*, *THD*, and the *SINAD*. The SINAD may be trivially transformed into the *ENOB*, which is the best overall single metric of digitizer performance. We reported upon a 12-bit GaGe digitizer that has achieved excellent performance at near 200 MHz with slightly compromised performance at 10 MHz. In choosing a digitizer, a user must carefully consider both the operating signal frequency range and the performance needs. A good rule is to target a digitizer input bandwidth that is high enough to meet the signal frequency requirements but no higher.

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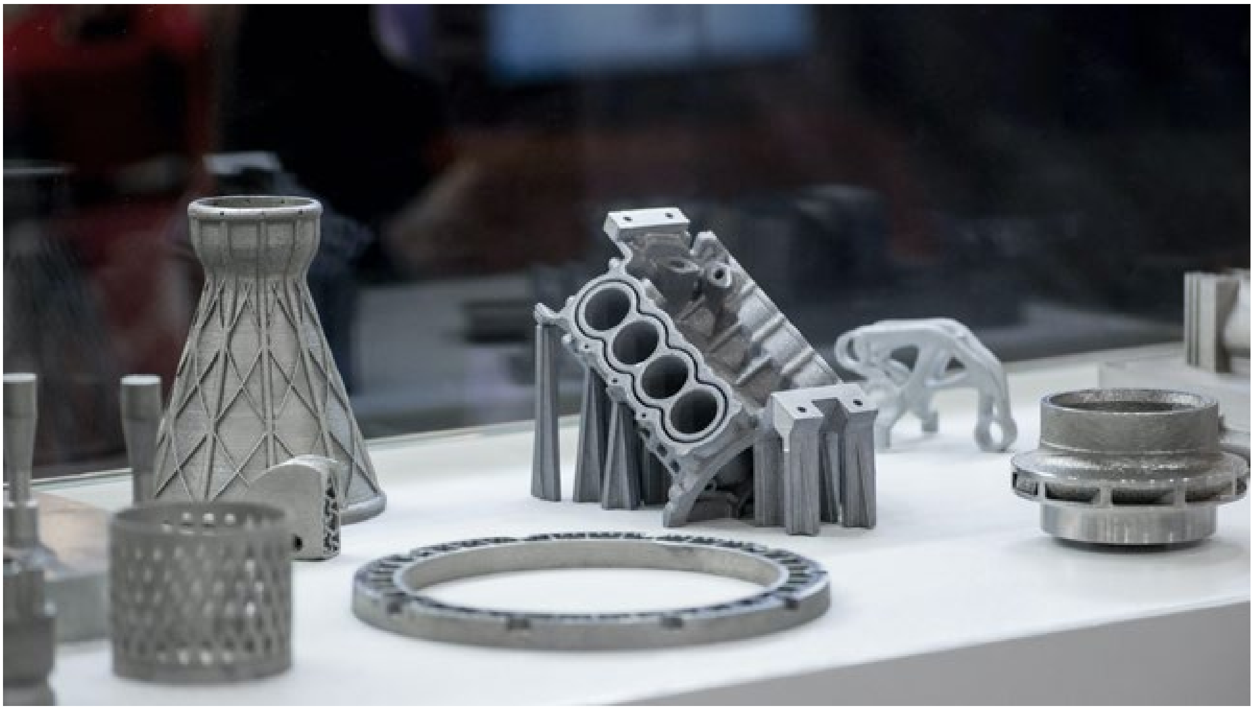
Additive Manufacturing: New Frontiers for Production & Validation

Peter de Groot
Zygo Corporation



Introduction

Over the last few decades, additive manufacturing (AM)/3D printing has fundamentally changed the way that manufacturers approach product development. Industry is now almost universally aware of the term rapid prototyping, using AM to convert 3D CAD data into physical models in a matter of hours. The role of AM in prototyping has become embedded across all industrial sectors.

AM has enabled concurrent engineering—where all relevant departments can be engaged early in the product development process. Concurrent engineering replaces traditional "over-the-wall" product development, where design iterations could be delayed by weeks to accommodate tooling and machining considerations. The benefits are dramatic time-to-market reductions and cost savings in product development.

AM is a uniquely disruptive technology. 25-30 years ago, it changed the manufacturing paradigm by altering the way that manufacturers produced prototypes. Today, it is disrupting the way that manufacturers produce end-use parts and components and is increasingly seen as a truly viable production technique. Now the conversation among manufacturers is around the most judicious use of AM for production, its advantages, the sweet spot is in terms of production volumes, key opportunities, and barriers to entry. Many of these barriers relate to precision quality control of AM parts, which challenge traditional methods of surface metrology.

Good Enough?

With the focus today being on the use of AM for production, the analysis of the accuracy and repeatable tolerance attainment of AM has become a far more critical issue. When used as a prototyping technology, absolute adherence to tolerances and precise design intent is not always necessary, and a "good enough" approach can be taken. Hence the proliferation of inexpensive desktop 3D printing machines that provide sufficiently accurate rapid prototypes that do the job without needing to be perfect.

For production applications, however, "good enough" is no longer sufficient. If an AM part is integral to a safety critical aerospace or medical application, it is essential to achieve dimensional and material tolerance targets consistent with design intent. It is here that the role of metrology to validate the quality of finished parts is so important. It is also an area where providers like ZYGO of 3D optical metrology solutions can make a difference.

Industry Response

Legacy manufacturing processes for metals and plastics have established quality control methods for validating and measuring parts. The production processes are understood, as are the most critical dimensional and surface finish requirements. AM, however, does exactly what the name implies—it produces parts layer by layer "additively,"and this opens up an array of unique issues that can affect the integrity of a finished product, and also a unique set of surface characteristics that make the job of measuring and validating that much more difficult.

How the sector is responding to the metrology and validation conundrum was highly visible at the recent (and largest) AM-related event on the calendar, Formnext in Frankfurt, Germany in November 2021. At various learning events on-site, metrology issues featured prominently, acknowledging the fact that measurement and validation of AM parts is a big deal today. In addition, AM technology providers are now developing in-process metrology (IPM) solutions to overcome the specialized challenges of verifying the integrity of AM processes.

AM technologies and metrology techniques have also captured the attention of professional societies that organize conferences and symposia worldwide. These include the American Society of Precision Engineering (ASPE), the International Society of Optics and Photonics (SPIE), and the International Academy for Production Engineering (CIRP).

Research in AM Metrology

In the search for relevant metrology critical to process control, industry is still trying to understand what to look for on and under the surface of an AM produced part, and how these relate to part functionality. Surfaces of AM parts challenge existing surface topography measurement and defy characterization using standardized texture parameters because of high surface slopes, voids, weld marks, and undercut features.

An area of active research is directed to the physical modelling of optical measurements of surface structures. Significant advances are needed to understand even established optical methods, for the purposes of instrument optimization and uncertainty analysis. Current approaches include Fourier optics analysis using conventional scaler diffraction theory, applied to a wide range of imaging and topography measuring techniques. However, these methods tend to be limited to smooth surfaces such as optical components, and are not directly applicable to complex, steeply sloped surfaces characteristic of AM parts, which generate multiple scattering and nonlinear response in optical instruments. For these situations, more advanced, rigorous methods including boundary-element methods and rigorous coupled wave analysis are of increasing interest for AM surfaces. Applications-oriented research is also growing, including best practice configuration of instruments for complex surface structures, in view of the behaviour predicted by advanced models.

Research into new and improved metrology for AM is advancing through a wide range of industry and academic partnerships, many in cooperation with ZYGO. An example is work at the University of Nottingham, where the Manufacturing Metrology Team (MMT) led by Professor Richard Leach is investigating the full range of solutions, from high-precision interference microscopy to X-ray tomography of the internal structure of completed parts.

In just the past four years, the MMT has published 43 research papers on AM, ranging from methods to optimize measurements on specific instruments to new feature-based analysis and machine learning to interpret results. Of particular interest is IPM for evaluating the quality during manufacture, following each additive line and layer in real time. This information can be used to inform control strategies and later in-process metrology developments. An important part of IPM development is correlating to reference metrology, including benchtop surface metrology instruments.

Another example of leading-edge research is at the University of North Carolina at Charlotte, where Professor Christopher Evans and co-workers have been using interferometry and electron microscopy to study AM materials in collaboration with the US National Institute of Standards and Technology (NIST), and Carl Zeiss GmbH at Oak Ridge National Laboratory (ORNL). These researchers have been studying Inconel 625—a high temperature Ni superalloy for AM, that exhibits an intriguing variety of surface signatures. These surfaces have areas rich in oxide films that are visible in true-colour, 3D surface topography maps obtained with ZYGO's interference microscopes. These instruments also serve as excellent workhorses for examining large areas with high detail, such as distorted weld pools, by assembling or 'stitching' together multiple high-lateral resolution images each with millions of data points.

While the challenges of quality control of AM parts are a great concern for those who make these parts, these same challenges present an attractive opportunity for new solutions and spinoff businesses. Founded in 2018 in the UK, Taraz Metrology is an example of a spinoff enterprise which combines university research, practical engineering, and commercial experience into a unique product development capability customized to the needs of AM. Taraz currently offers freestanding final inspection solutions for all types of AM parts and leverages proprietary software for advanced fringe projection and photogrammetry of topography.

Standardization and Traceability

The ability of AM to produce geometrically complex parts, its role as an enabler of mass customization, and the potential time and cost savings associate with its use are all important for the future of industry. However, when compared to more familiar and established manufacturing methods, AM technology is dynamic and rapidly evolving, and technology innovators are working to overcome the barriers to adoption of AM for production applications, including those related to quality control standards.

Just acquiring dimensional data from AM surfaces is already a significant challenge, but the next step is to establish confidence in the results. The expanding range of application for optical measurements is driving active research in calibration, traceability, and verification for surface topography measurements. ZYGO is working with international collaborators on instrument specification within a general calibration framework based on the metrological characteristics of topography-measuring instruments for advanced manufacturing.

Given the critical nature of data confidence, there are now major international projects linking academics, instrument makers and national metrology institutes with the specific goal of better understanding the data from optical sensors. As an example, ZYGO is a partner in the €2.2M EMPIR 20IND07 TracOptic project, with the title "Traceable industrial 3D roughness and dimensional measurement using optical 3D microscopy and optical distance sensors" —of obvious value to the AM sector.

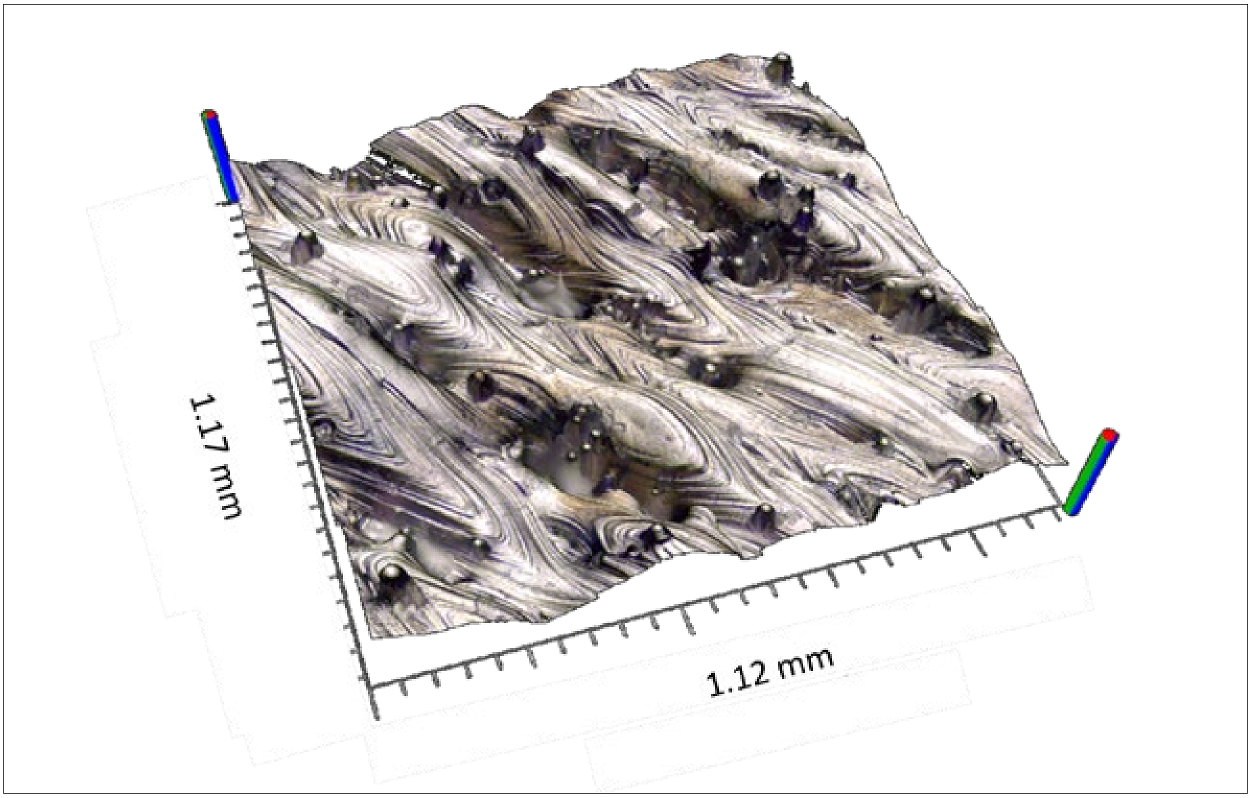


Figure 1. ZYGO's true-colour interferometric topography measurements of Ti-6Al-4V laser powder bed fusion sample provided by the University of Nottingham illustrates the unusual and challenging surface structure of AM parts. The height range for the topography is 150 µm.

National and international standards are critical both to Industry adoption and to assuring quality control across multiple, developing manufacturing technologies. A clear example is current work within ISO TC213 WG16 to develop the ISO 25178 surface texture standards, including the ISO 25178-603 and 25178-604 standards for interference microscopy, and the 25178-700 standard for instrument calibration and traceability. These developments are directed towards greater consistency in instrument specification, while providing default methods for verifying expected performance.

Post-Process Metrology

Measurements of AM parts post-process serve to validate conformance with design intent, and to provide clues into fabrication problems left by surface signatures. However, the uniqueness of AM processes and produced parts lead manufacturers to use an array of different mechanical and metrology verification techniques. They adopt an empirical approach as no one solution is trusted to provide accurate enough data. Gage R&R is used as a stand-in for a more rigorous measurement uncertainty approach. As a consequence, AM parts are often "over-tested" to improve confidence, but this means extra time and extra cost, areas that must be addressed to make AM for production more viable.

The open question is how to improve this situation for greater efficiency while maintaining confidence. The answer is for metrology solutions providers to adapt existing metrology technologies to better align them with the unique characteristics of the AM process and end-use AM parts, which are characterized by irregular, steeply sloped surface topography that many measurement technologies fail to capture.

Through research and development of the foundational coherence scanning interferometry (CSI) technology in the ZYGO 3D optical profilers, high-accuracy AM metrology tools are now available to industry. These instruments use innovative hardware and software upgrades, the package of improvements referred to as "More Data Technology," which makes the instruments better suited to AM parts.

"More Data" significantly improves the baseline sensitivity of CSI and enables high-dynamic range (HDR) operation making it valuable for a wide range of parts, from steeply sloped smooth parts to exceptionally rough textures with poor reflectivity. Additionally, HDR measures parts with a wide range of reflectance, often a struggle for other instruments that use interferometry as a measurement principle. These advances make it possible to create full-colour surface topography images of metal additive manufactured surfaces using interferometry (see Figure 1).

Summary

With AM now an established production technology for certain applications, there are barriers to mass adoption that are being addressed, including the need for in-process and post-process metrology technologies that can validate the quality and accuracy of the parts produced. AM parts have a unique set of characteristics that render traditional measuring technologies impotent in some situations, and today, innovative metrology technologies are being developed that can provide meaningful measurement data efficiently and cost-effectively. Only when such issues are addressed will the use of AM become mainstream as a viable production technology across an array of industry sectors and applications.

Acknowledgements

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Peter de Groot, PhD, is Chief Scientist at Zygo Corporation, which is owned by AMETEK, Inc., a leading global manufacturer of electronic instruments and electromechanical devices with annual sales of approximately $5 billion. ZYGO designs and manufactures optical metrology instruments, high-precision optical components, and complex electro-optical systems. Its products employ various optical phase and analysis techniques for measuring displacement, surface shape and texture, and film thickness. Electro-Optics and Optical Components businesses leverage ZYGO's expertise in optical design and assembly, and high-volume manufacturing of precision optical components and systems, for the medical/life sciences, defense and industrial markets.

Metrology Across the Ages

Dan Wiswell
Cal-Tek Company, Inc.

I'm not sure when it occurred exactly, but sometime during the age of reason there used to be an educated group of people that were called philosophers. The term itself defined these individuals as "Lovers of Wisdom" and set them apart in a time before science focused the inquisitive mind of humanity. As science slowly began to replace alchemy and magic, scientific thought and reason replaced myth and superstition. Through this process the modern world evolved and philosophers were transformed into what we now call scientists.

As science morphed into a myriad of disciplines, our modern understanding of the universe began to take shape. That is not to say that the ancient world was devoid of invention and scientific discovery. We only need to look back at things like the Antikythera Device and other similar creations to dispel that notion. Warfare has always been a catalyst for invention. Siege engines used in military campaigns are where we get the word engineer, which is the term used to describe the people that manipulated, labored under and maintained those machines.

In the seventeen century the pace of technological advancement began to increase dramatically. The science of measurement was nurtured by the efforts of people like Galileo Galilei, Tycho Brahe and Antoni van Leeuwenhoek along with countless others, many of whom are now forgotten by time. They advanced the states-of-the-arts left to them by people like Nicolaus Copernicus and Leonardo da Vinci, to whom we are all now indebted. Isaac Newton furthered our understanding of optics in more ways than anyone else had ever been able to articulate, and he sparked the imaginations of countless individuals that ultimately led to the deployment of the Webb Telescope. Many had to suffer the consequences of being considered too forward looking, and for being out of step with contemporary theology.

The eighteenth century brought to science experimentations with naturally occurring electricity that gave us the first electrical components like the Leiden Jar, which we now call the capacitor. The development of electro-mechanical devices in the eighteenth and nineteenth centuries heralded an explosion of innovation. Alessandro Volta invented the modern battery in 1800. Andre-Marie Ampere, known as one of the founders of electrodynamics is credited as having invented the solenoid and the first electrical telegraph. Georg Ohm put all of those discoveries together, and in 1841 won the Royal Society's Copley Medal for defining what we now call Ohm's law.

The stage was set by these founding fathers for rapid advancements in our own field, the study of Metrology. About thirty years after Ohm's signature achievement, Lord Kelvin created and then refined his galvanometer. This device was not only the first instrument of its kind to measure a quantity of electrical current, it also had the unique ability to show the absence of the flow of electrical current, as it was based upon an electrical meter movement that was zero-centered. This may not sound like an important innovation, but it allowed for the creation of electrical bridges in which a known quantity of electromotive force could be measured against an unknown quantity. It could also be used to connect an unknown value in opposition to a known similar value to determine the unknown value of a broad variety of electrical parameters like resistance, capacitance, temperature and even such esoteric things as transformer turns ratios.

The introduction of Lord Kelvin's galvanometer was followed shortly thereafter by the first mass-produced meter movement created and patented by Jacque-Arsene d'Arsonval and Marcel Duprez in 1882. This device utilized a coil of wire suspended in a magnetic field. It was set in place by an adjustable pivot-and-jewel assembly that was tensioned by hairsprings in such a fashion that a needle (or pointer) would track an arc that could be delineated by a hand-pointed scale. The entire assembly was balanced by copper weights or, in some instances, beeswax so that it would accurately provide indications regardless of the orientation of the movement. Many attributes of this technology had been developed more than a century prior to its emergence from methods employed by horologists as they perfected the art of manufacturing clocks and watches. It should be noted though, that just like many innovations, it takes the observations and dedication of one individual to change the course of human events. Mssr. Jacque-Arsene d'Arsonval will be remembered as such an individual.

In subsequent years the d'Arsonval movement was improved upon by Edward Weston when he patented his meter movement in 1888. It has always amazed me that two years before the invention of Weston's meter movement the Edison Electric Illuminating Company of Boston was founded. In those days it must have been an exciting but dangerous time to be an electrical engineer.

The Weston meter movement became the mechanism of choice for nearly every manufacturer of electrical instruments in the United States in the late nineteenth and early twentieth centuries. Although other meter movement technologies existed in the following years such as iron-vane and electrostatic repulsion movements, to name a few, none were as widely used as the Weston movement. Suddenly, there was a technological explosion in the instrument industry that grew simultaneously with the newly created consumer appliance market. Instrument manufacturing companies employed thousands of workers in cities and towns all over the United States. A golden age of instrument design arose. Instrument manufacturers crafted products that were pleasing to both sides of the brain, expertly merging art with science. Elegant instruments began to appear. Manufacturers like Shallcross Manufacturing Company, Leeds and Northrup, and the Griebach Instrument Corporation began replacing the pointers on their meters with mirror-based meter movements that would optically project an image of a stylus that trans versed a meter scale. New instrument companies appeared all over the United States and the rest of the developing world. Dozens of panel meter manufacturers offered a variety of solutions to suit the needs and the ascetic tastes of their customer bases.

As is the case with many technologies, meter movement designs were not just improved by the needs of the market, but also by the advancements that are often caused by conflict. During the first and second world wars it became evident that critically important ship-board instruments were susceptible to damage caused by the concussion of ordinance and by the detonations of depth charges inflicted during submarine warfare. The engineered response however, took some time. It wasn't until the end of the 1940s that advancements in materials research allowed for the creation of a new style of meter movement. New, ruggedized meters replaced pivot-and-jewel based movements that featured taut-band designs by utilizing high-strength alloys, which also negated the need for hairsprings in their assemblies. Taut bands in these newer meter movements suspended the moving coil with phosphor-bronze leave springs, which proved to be much more durable in harsh operating conditions.

As the twentieth century progressed, advancements in display technology began to chip away at the dominance of electro-mechanical instrument displays. The advent of digital circuitry also improved the accuracy and resolution of measurements significantly. An example of this is that prior to digital display technology, frequency measurements could not be expressed in any way nearing the ability of digital display resolution. But advances in technology always seem to move forward in fits and starts. The early Soviet space capsules featured an electro-mechanical display, with a representation of the Earth that rotated as it displayed to the cosmonauts the approximate location of where they were as they orbited above the Earth's atmosphere.

In the western world, by the 1950s display manufacturers on the cutting edge of technology began competing with analog meter manufacturers by replacing them with digital meters sporting gas-plasma nixie tubes and other types of PCB-mounted, neon-based plasma displays with no moving parts. Edge-lit lucite blocks with etched numerical digits appeared briefly before being replaced entirely by LED displays. Instruments with Electro-florescent displays were designed for low light level environments. Early on, cat's eye tubes, followed by oscillographic, and then picture tubes became features of mid-century front-panel design. Liquid Crystal Displays first appeared in 1968, which diminished the role of meter movements in display technology even further. It almost goes without saying that TFT displays are out-performing the devices imagined in science fiction of the 1960s. Over the past few decades, as computer screens have replaced many of the older display technologies, the internet has turned remote telemetry into a ubiquitous feature of the modern world.

As we stand back and see the ways that measurement technology has transformed society, we should all take a moment to marvel at the achievements brought forth by such humble beginnings. Because at a fundamental level, we have always created measuring devices so that we may extend our senses to perceive the phenomenon that surround us at the limits of our perception. And as we segue into the future, who knows? Maybe even King Tutankhamen himself was buried with an ancient Egyptian app for that.

Dan Wiswell (dcwiswell@repaircalibration.net) is a self-described Philosopher of Metrology. He is President/CEO of Cal-Tek Company, Inc. and Amblyonix Industrial Instrument Company.

NEW PRODUCTS AND SERVICES

Image Credit: Chroma Systems Solutions, Inc.

Chroma Releases Triple Output High Power Programmable 1U DC Power Supplies

Chroma's new high power programmable 62000E DC Power Supplies provide three isolated 1.7kW channels with independent control of voltage, current, and measurement with WiFi control at 1U high.

FOOTHILL RANCH, Calif. - Jan. 24, 2022 - PRLog — Chroma Systems Solutions, a leading provider of power conversion automated test equipment, releases a new line of single and three channel programmable 1U DC Power Supplies. Chroma's new high power programmable 62000E DC Power Supplies provide three isolated 1.7kW channels with independent control of voltage, current, and measurement. Single channel units provide 1.7kW, 3.4kW, and 5kW output; up to 20kW in parallel. In total, the 62000E series is comprised of 28 fixed-range and auto-range output models in total with current ratings up to 22.5A and voltage ratings up to 1200V.

The 62000E DC power supply provides constant voltage (CV) and constant current (CC) modes for switching the output to meet testing requirements. Along with Chroma's integral settings for high precision, their high-speed transient response and low output noise functions are thoughtful additions for system integration and lab testing. Applications include design validation, functional testing, and reliability testing of DC to DC power systems, automotive components, aerospace and satellite power systems, active and passive components, as well as aging testing for industrial and medical system power supplies, semiconductor power components, LED and laser diodes, and solar module production. When integrating into multi-channel systems, three channels per unit significantly reduces required rack space and simplifies cable configuration.

To meet various test requirements these DC supplies have built-in List and Step modes to program the sequence and timing. Through software, units can support 100 steps of dwell time ranging from 10ms to 65535s and voltage and current control as well as I/O signal output for automated testing. These functions are used for voltage drop tests on DC converters and inverters, automotive battery charging, lifecycle testing of components, and aviation testing.

Easily adapting and saving electricity costs to power systems all over the world, the 62000E Series DC power supply accepts single- or 3-phase 200 ~ 240Vac and 3-phase 380 ~ 400Vac input with active PFC and a high efficiency of 92%. In addition, control of the 62000E is supported by digital USB, LAN (LXI), CAN FD, GPIB, and analog APG interfaces. Other features include a touch screen to edit settings and a VPN wireless interface for secure WiFi remote control from your phone or tablet.

Chroma manufactures power conversion and electrical safety automated test equipment for the next generation of technologies. For more information on Chroma's new auto-ranging three channel 62000E DC Power Supplies, visit to https://www.chromausa.com/product/programmable-dc-power-supply-62000e/ or call us at (949) 600-6400.

Ralston Process Meter LC30

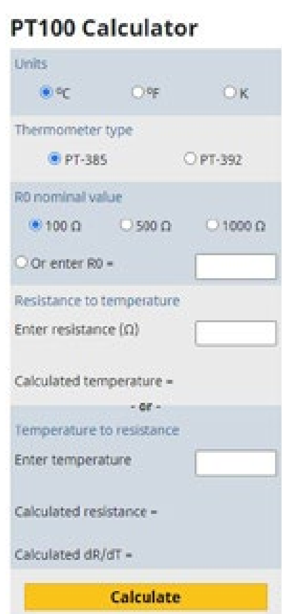
The new Process Meter LC30 is a reference-grade digital gauge that's optimized for fixed installation in panels and enclosures. With impressive +/-0.1% full scale accuracy, intuitive controls, and convenient design features for easy installation, there's no better choice for lab and OEM applications that require high-precision from a panel-mounted gauge.

Perform live viewing of pressure or set up tests for continuous monitoring, and easily customize the gauge to your needs using the included FieldLab calibration management software.

Designed to run on AC power, the Process Meter LC30 includes country adapters for Canada, US and Europe, with backup battery power. It's available in 11 pressure ranges from 5 psi to 10,000 psi (35 kPa to 70 MPa), a combination pressure/vacuum gauge from +/- 15 psi (+/-100 kPa), and a vacuum gauge measuring up to 30 inHg (760 mmHg).

For more information go to: https://www.ralstoninst.com/lc30-digital-pressure-gauge

New PT100 Calculator by Fluke Calibration



Fluke Calibration just created a new PT100 Calculator: https://us.flukecal.com/pt100-calculator.

The new online tool will calculate temperature and resistance values from the standard PT100 curves. Select the temperature unit, type of PT100 curve you need, PT-385 or PT-392, and the R0 (resistance at 0 °C) value.

The calculator will produce a temperature value from an entered resistance or calculate resistance and thermometer sensitivity values from an entered temperature.

To find this and other online tools Fluke Calibration has available, visit: https://us.flukecal.com/support/tools

Release of Metrology.NET® V.2!

Aurora, CO, January 20, 2022 — Cal Lab Solutions, Inc., a metrology software and consulting company, announces the release of Metrology.NET V.2. Now a mature product, Metrology.NET is 21st century engineered software, incorporating scalable, low-code solutions for the calibration lab. Features with Metrology.NET V.2 include:

- **New Look** - Originally designed with mobile devices in mind, the updated version continues to prioritize form and function with a user-friendly and intuitive interface.
- **Updated Capabilities** - By utilizing Amazon Web Services Code Deploy Agent, updates can now be applied seamlessly, so if you are in the middle of an automated calibration, it will not be interrupted. Auto Scaling has also been implemented to boost performance when necessary.
- **Scalability** - Metrology.NET can be implemented in your lab through a cloud-based, hosted system or stand-alone on your company servers. Additionally, you have the option of utilizing a pared down "slim" version of the software. Custom development can integrate Metrology.NET to work with your existing lab software.
- **Starter Pack** - Our Starter Pack comes with any new implementation of Metrology.NET and includes over 400 test packages for a variety of UUTs such as power supplies, oscilloscopes, and analyzers. Metrology Blocks is a tool that also comes with Metrology.NET and makes building your own test packages easy.

With today's shortage of qualified technicians, calibration labs need automation that is fast to develop, easy to run, and doesn't stop production when there's a problem. To learn more, visit https://www.metrology.net. Email sales@callabsolutions.com or call (303) 317-6670 - MST to schedule a demo of Metrology.NET Version 2.0 today!

About Cal Lab Solutions, Inc.

Cal Lab Solutions, Inc. is a metrology based software engineering company located in Aurora, Colorado. We develop both customized and off-the-shelf software in Metrology.NET and Fluke MET/CAL, as well as generic, stand-alone procedures for various T&M equipment from DC to lightwave. Our Metrology.NET system and drivers provide support for self-maintainers of RF and microwave, pressure, DC and low frequency, torque, temperature, flow, force, humidity, mass, etc. We also provide consulting and engineering of calibration workstations for electrical and RF and microwave T&M equipment.

Additel's New 282 Dual Channel Reference Thermometer

With accuracy capabilities on par with laboratory grade thermometers, the Additel 282 is capable of handling even your most critical measurements. This ultra-high precision handheld readout features dual analog channels designed to facilitate comparison measurements and meet all of your temperature measurement needs. The easy-to-use touchscreen makes navigating the well-designed menus a time saving and enjoyable experience. The Lemo style smart connectors help to ensure that your probe calibration information is never in question. The ADT282 Reference Thermometer Readout helps makes metrology simple and will quickly become your new go-to when reliable temperature measurements are a must.

Additel's 282 reference grade readout provides a temperature measurement accuracy as good as 0.005°C (readout only), with a typical system uncertain of approximately 0.013°C @ 0°C when coupled with a capable PRT. This new temperature meter is loaded with features such as dual channels, RTD & thermocouple measurement capabilities, cold junction compensation for more accurate TC measurements, a large smartphone like display, Bluetooth and USB communications, a built-in easy to access sensor library, datalogging capabilities, an IP67 rating and a rechargeable lithium battery.

Product Availability

The Additel 282 Dual-Channel Reference Thermometer Readout are available now. For more information, please visit www.additel.com. For information about other Additel products and applications, or to find the location of your nearest distributor, contact Additel corporation, 2900 Saturn Drive, #B, Brea, CA 92821, call 1-714-998-6899, Fax 714-998-6999, email sales@additel.com or visit the Additel website at www.additel.com

About Additel

Additel Corporation is one of the leading worldwide providers of process calibration tools. Additel Corporation is dedicated to the design and manufacture of high-quality handheld test tools and portable calibrators for process industries in precision pressure calibration and test instrumentation. With more than 20 years in the industry, Additel has successfully developed Dry Well Calibrators, Thermometer Readouts, Pressure Controllers, Portable Automated Pressure Calibrators, handheld Digital Pressure Calibrators, Documenting Process Calibrators, Multifunction Process Calibrators, Digital Pressure Gauges, and various Calibration and Test Pumps.

Continuous Integration

Michael Schwartz & David Kimery
Cal Lab Solutions, Inc.

With today's worldwide cloud-based computing solutions, downtime is not an option! Not even for scheduled system maintenance and updates. Customers want ZERO downtime, no exceptions.

But how can we, as software developers, keep a system up and running while we are updating the code to add features or resolve bugs? The solution is not easy, but it is possible.

Ever since I learned the Intuit team was developing online tax solutions that could post an update while customers were using their software, without shutting down the servers, I said this was something I wanted my software to do. So we started investigating the solution and the requirements.

The first thing we had to do was completely re-write the user authentication layer and services architecture to the software. Without getting too technical, most web applications running in HTTPS maintain a secure encrypted connection between the web browser and the server. This is usually done through session state.

If you have ever been using your browser and all of a sudden the server says you need to log back in, chances are you have lost the session state/secure communications between the server and your browser.

This was the first problem we had to solve, allowing the session state to move securely between one server to the next. This is not a new technology; many of the larger websites/services can already do this, it was just a matter of learning how to do this in our software.

We decided to go with Amazon Web Services AWS, implementing a load balancer and the option of one server or multiple servers, each load balanced based on the site traffic. Hence, the load balancer's job is to balance the workload between the servers.

The first step to make this work, we have to move the user's session state from the web server application to a database. This allows the load balancer to move a user from server A to server B without breaking the session state.

Once this task is complete, then some continuous integration magic can start to happen. With a little bit of scripting, we can now test new features and bug fixes in a live environment via our test server before deploying to production[1]. When the update is ready, the Code Deploy Agent's Application Specification file takes over and manages the deployment scripts via event hooks. The Agent spins up a new instance on AWS, installs the update, runs our builds, and starts up the web server application[2,3]. If the deployment succeeded with no errors, traffic to the old instance is blocked and traffic to the new instance is allowed through via the Load Balancer.

Once the deployment is complete, the old instance will be terminated and removed from the server farm. If a deployment fails for any reason, a rollback will be performed so the prior instance will still be in service.

Next, we set our system up with AWS Autoscaling. This allows us to add and remove servers based on CPU usage. For example, if the server(s) are running at 70% or higher usage then AWS will automatically spin up a new server, launch the last successful Code Deployment, and balance the load across the instances. Then if we post a new update, AWS will populate the update across the deployment groups one instance at a time.

So, the next question is "Really… Does it actually work?" The answer is "Hell Yea!" That is why I am writing this automation corner! When I was a calibration technician, I used to hate that I couldn't run a calibration procedure overnight. The IT group had to shut down the database to perform a full backup. If my procedure lost connection to the database, all my calibration data was lost and I had to start over.

Last week I was in the process of doing two demos. In one of the demos, the customer was going to calibrate an HP 34401A. While the calibration was running David sent me a WhatsApp message. He just fixed an error the customer found in the previous demo. Should he post the update or wait until I was done with the demo?

I said, "Post it!" The deployment groups posted the update to our test and production servers then updated the load balancer. Everything ran perfectly! The calibration we were running didn't lose a single test point!

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1 https://aws.amazon.com/devops/continuous-integration/
2 https://aws.amazon.com/codedeploy/faqs/
3 https://docs.aws.amazon.com/codedeploy/index.html

“METROLOGY SINE QUA NON”

MSC Training Symposium

Anaheim, California - May 16-19, 2022

The symposium has promoted education and professional excellence in the measurement sciences for over 50 years. The 2022 MSC theme is: METROLOGY SINE QUA NON – “Nothing is possible without metrology.” The MSC will offer many exceptional measurement related courses taught by industry and government experts, as NIST Seminars, Tutorials, ASQ and Hands On Sessions.

NIST training seminars

- Gas Pressure Measurement via Fixed Length Optical Cavity (FLOC) Pressure Standards
- Calibration of Mass in the “New SI”
- Humidity
- Hands-on Workshop on Assessing and Reporting Measurement Uncertainty
- Selection, Calibration, and Use of Contact Thermometers

Full and Half day tutorials

- Best Practices in Evaluating Measurement Uncertainty
- Practical Approach to Thermocouple and RTDs
- Design and Construction of A Gas Flow Calibrator
- Back-to-Basics Metrology 101

There is still time to submit a paper for presentation or to host a class!

Send a brief synopsis and a brief bio to: mscorg.info@gmail.com.

For an updated schedule of educational opportunities and how to register, visit:

msc-conf.com

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www.additel.com
Phone: 714-998-6899
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Corporate Headquarters
2900 Saturn Street #B
Brea, CA 92821, USA