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THE INTERNATIONAL JOURNAL OF METROLOGY

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How Low Can My Load Cell Go?

Deconvolution-Based Time Response Measurement for Wideband Power Sensors

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FEATURES

DEPARTMENTS

ON THE COVER: Temperature metrologist, Toby Hopcraft, repairs a Hart Scientific 6035 calibration bath in the temperature lab at JM Test Systems' new facility in Baton Rouge, Louisiana.

CALENDAR

UPCOMING CONFERENCES & MEETINGS

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

May 20-23, 2024 IEEE International Instrumentation and Measurement Technology Conference (I2MTC). Glasgow, UK. The flagship conference of the IEEE Instrumentation and Measurement Society, dedicated to advances in measurement methodologies, measurement systems, instrumentation and sensors in all areas of science and technology. https://i2mtc2024.ieee-ims.org/

May 27-29, 2024 24th International Conference on Metrology and Properties of Surfaces. Marrakech, Morocco. The 24th International Conference on Metrology and Properties of Surfaces (Met&Props) will contain a broad array of scientific themes including, surface characterization, measurement and instrumentation, in-process surface metrology, archaeology and anthropology and forensic science. https://metprops2024.org/

Jun 3-5, 2024 11th International Workshop on Metrology for AeroSpace. Lublin, Poland. MetroAeroSpace aims to gather people who work in developing instrumentation and measurement methods for aerospace. https://www.metroaerospace.org/

Jun 11-13, 2024 SENSOR+TEST. Nuremberg, Germany. When SENSOR+TEST – the leading international trade fair for sensor, measuring and testing technology – opens its doors again on Tuesday, 11 June 2024 under the motto "Welcome to the Innovation Dialogue!" visitors can expect three days of pure technology with innovations to touch. https://www.sensor-test.de/en/

Jun 12-13, 2024 CEESI Gas Ultrasonic Meter User's Conference. Colorado Springs, CO. This conference provides a forum for ultrasonic meter manufacturers and end users to discuss measurement challenges in the hydrocarbon measurement industry. https://www.ceesi.com/

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EDITOR'S DESK

A Wider Community

This spring, our online calendar was filled with the bright colors of metrology events going on all over the world. Despite the talk of divisiveness and people working from home, it goes to show that people really like to get together and do stuff. The smaller conferences and meetings have many elements of a neighborhood block party or city fair, complete with vendors, food, and information exchange.

Our home town of Aurora, Colorado, will be hosting this summer's NCSLI (https://ncsli.org/) and CPEM events at the brand-new Rockies Gaylord venue. Each year, the city of Aurora has an International Festival to celebrate the different cultures of our bustling community. It features vendors, performers, and representatives of immigrant communities I wasn't aware existed in our humble town.

The metrology world has its communities too; you could give yourself a headache trying to categorize all the associations and industries within a single country, let alone the world. So just by going to one metrology event, you learn how your little world connects to a wider community.

In this issue, Henry Zumbrun discusses the impact on measurement uncertainty of using a load cell as low as 2% of its rated capability, in his article "How Low Can My Load Cell Go?"

Then Lichun Wang and Yifan Zhang, of Keysight Technologies, explain deconvolution, as an alternative to RSS calculation, when measuring a power sensor's time response in their paper titled "Deconvolution-Based Time Response Measurement for Wideband Power Sensors." It's always nice to get papers from around the world; the metrology community is truly an international one.

Most of the calendar events listed in this issue are also online at **callabmag.com/calendar**. It's a no frills Google calendar, but filled out with every metrology event I can find, so be sure to check it out!

Happy Measuring,

Sita Schwartz

CALENDAR

Jun 16-21, 2024 IEEE International Microwave Symposium (IMS). Washington, DC. The IEEE International Microwave Symposium (IMS) is the world's foremost conference covering the UHF, RF, wireless, microwave, millimeter-wave, terahertz, and optical frequencies. https://www.ims-ieee.org/

Jul 6-10, 2024 NCSLI Workshop & Symposium/ Conference on Precision Electromagnetic Measurement. Denver, CO. The theme for this joint event with CPEM and NCSLI Workshop & Symposium will be "Innovation through Measurement: A Focus on Critical and Emerging Technologies." https://ncsli.org/

Jul 22-25, 2024 Coordinate Metrology Society Conference. Charlotte, NC. The Coordinate Metrology Society (CMS) is excited to unveil the grand celebration of its 40th Year Anniversary! https://www.cmsc.org/conference

Aug 26-29, 2024 IEEE AUTOTESTCON. National Harbor, MD. AUTOTESTCON is the world's premier conference that brings together the military/aerospace automatic test industry and government/military acquirers and users to share new technologies, discuss innovative applications, and exhibit products and services. https://www.autotestcon.com/

Aug 26-29, 2024 IMEKO 2024 XXIV World Congress. Hamburg, Germany. Organized by Physikalisch-Technische Bundesanstalt (PTB), the theme of the congress is "Think Metrology." https://www.imeko2024.org/

Sep 22-27, 2024 European Microwave Week (EuMW 2024). Paris, France. The 27th edition of the European Microwave Week (EuMW 2024) will come to Paris to continue the annual series of highly successful microwave events that started back in 1998. EuMW 2024 comprises three co-located conferences: The European Microwave Conference (EuMC), The European Microwave Integrated Circuits Conference (EuMIC), The European Radar Conference (EuRAD). https://www.eumweek.com/conferences/general_info.html

CALENDAR

SEMINARS & WEBINARS: Dimensional

May 21-23, 2024 Gage Calibration Methods Class. Cincinnati, OH. QC Training. A hands-on workshop, offering specialized training in calibration and minor repair for the individual who has some knowledge of basic Metrology. https://qctraininginc.com/course/gage-calibration-methods/

Jun 25, 2024 Introduction to Dimensional Metrology Hand Tools I – Fundamental Tools. Aurora, IL. Mitutoyo. EDU-101 is a one-day class for entry-level team members who need to learn the fundamentals of the steel rule, caliper, micrometer, pin gage, and gage block. https://www.mitutoyo.com/training-education/classroom/

Jun 26-27, 2024 Dimensional Gage Calibration. Aurora, IL. Mitutoyo. EDU-113 is a two-day class that covers key principles of calibration, use of reference standards, reporting of results, and traceability. https://www.mitutoyo.com/training-education/classroom/

Aug 6, 2024 Introduction to Dimensional Metrology Hand Tools I – Fundamental Tools. West Chester (Cincinnati), OH. Mitutoyo. EDU-101 is a one-day class for entry-level team members who need to learn the fundamentals of the steel rule, caliper, micrometer, pin gage, and gage block. https://www.mitutoyo.com/training-education/classroom/

Aug 7, 2024 Introduction to Dimensional Metrology Hands Tools II – Surface Plate Tools. West Chester (Cincinnati), OH. Mitutoyo. EDU-102 is a one-day class for entry-level team members who need to learn the fundamentals of the surface plate, height gage, indicator and stands, angle block, v-block, and sine bar. https://www.mitutoyo.com/training-education/classroom/

Aug 8, 2024 Introduction to Dimensional Metrology Hand Tools III – Hole and Depth Tools. West Chester (Cincinnati), OH. Mitutoyo. EDU-103 is a one-day class for entry-level team members who need to learn the fundamentals of depth gages, telescoping gages, holtest gages, bore gages, and thread gages. https://www.mitutoyo.com/training-education/classroom/

Aug 20-22, 2024 Dimensional Gage Calibration and Repair. Aurora, IL. Mitutoyo. EDU-114 is designed specifically for those who plan and perform calibrations of dimensional measuring tools, gages, and instruments. https://www.mitutoyo.com/training-education/classroom/

Aug 29-30, 2024 Introduction to Dimensional Metrology. Pretoria, South Africa. NMISA. To obtain the basic understanding of Dimensional Metrology as use in measuring and inspection in industry. https://store.nmisa.org/collections/face-to-face-courses

Sep 24, 2024 Introduction to Dimensional Metrology Hand Tools I – Fundamental Tools. Aurora, IL. EDU-101 is a one-day class for entry-level team members who need to learn the fundamentals of the steel rule, caliper, micrometer, pin gage, and gage block. https://www.mitutoyo.com/training-education/classroom/

Sep 25-26, 2024 Dimensional Gage Calibration. Aurora, IL. Mitutoyo America's Gage Calibration course EDU-113 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/classroom/

Sep 27, 2024 Small Tool Repair Course. Aurora, IL. EDU-301 will focus on the care and repair of Mitutoyo small tools including calipers (digital and dial), micrometers (digital and mechanical), and indicators (digital, dial, and lever-style). This course does not cover laser or MDH high accuracy micrometers, LH-600 or QM height gages, or non-Mitutoyo tools. https://www.mitutoyo.com/training-education/classroom/

Oct 7-11, 2024 Advanced Dimensional Metrology. Pretoria, South Africa. NMISA. The course objective is to obtain an in-depth understanding of Dimensional Metrology. The course built on the Basic dimensional metrology course explaining the key principles and techniques used in dimensional metrology. https://store.nmisa.org/collections/face-to-face-courses

SEMINARS & WEBINARS: Education

Aug 15, 2024 Metric System Education Resources. Online. NIST. This 1.5-hour session will explore NIST Metric Program education publications and other resources teachers, parents, and students can download and freely reproduce. These resources are helpful to students as they

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become familiar with metric units, develop measurement quantity reference points, and learn more about SI basics. https://www.nist.gov/pml/owm/owm-training-and-events

SEMINARS & WEBINARS: Electrical

May 22-23, 2024 Electrical Measurement. Lindfield, NSW, Australia. NMI. This two day (9am-5pm) course covers essential knowledge of the theory and practice of electrical measurement using digital multimeters and calibrators; special attention is given to important practical issues such as grounding, interference and thermal effects. https://shop.measurement.gov.au/collections/physical-metrology-training

Jun 10-13, 2024 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

Sep 23-26, 2024 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. We will also teach techniques for making good high precision measurements using reference standards. https://us.flukecal.com/training

Nov 4-7, 2024 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

Jul 22-24, 2024 Calibration of Liquid Hydrocarbon Flow Meters. Londonderry NSW. National Measurement Institute, 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

Sep 16-20, 2024 Gas Flow Metrology. Delft, Netherlands. VSL. The training Gas flow metrology provides information about the backgrounds of gas flow and energy measurements and the pitfalls that can be encountered in these measurements. Participants will be able to immediately identify potential measurement problems and take appropriate measures. https://www.vsl.nl/en/services/training/

Sep 17-20, 2024 Gas Flow Calibration Using molbloc/molbox. Phoenix, AZ. Fluke Calibration. Gas Flow Calibration Using molbloc/molbox is a four day training course in the operation and maintenance of a Fluke Calibration molbloc/molbox system. https://us.flukecal.com/training

Sep 24-26, 2024 Seminar Flow Measurement and Calibration (Deutsch). Neufahrn, Germany. TrigasFI. This seminar is designed for those interested in purchasing, calibration, engineering, and all users of flowmeters. The focus is on the physical fundamentals, the functionalities of modern flow measurement techniques, the theory and technology of calibration as well as metrological traceability. https://trigasfi.com/

Sep 30-Oct 2, 2024 Seminar Flow Measurement and Calibration (English). Neufahrn, Germany. TrigasFI. This seminar is designed for those interested in purchasing, calibration, engineering, and all users of flowmeters. The focus is on the physical fundamentals, the functionalities of modern flow measurement techniques, the theory and technology of calibration as well as metrological traceability. https://trigasfi.com/

SEMINARS & WEBINARS: Force & Torque

Sep 9-13, 2024 Fundamentals of Torque Metrology: Practical Approach. Pretoria, South Africa. NMISA. At the end of the course, attendees should have a good understanding of the fundamentals of torque metrology principles and torque measurements. https://store.nmisa.org/collections/face-to-face-courses

Sep 16-20, 2024 Fundamentals of Force Metrology: Practical Approach. Pretoria, South Africa. NMISA. At the end of the course, attendees should have a good understanding of the fundamentals of force metrology principles and force measurements. https://store.nmisa.org/collections/face-to-face-courses

SEMINARS & WEBINARS: General

Jul 15-19, 2024 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/owm/owm-training-and-events

SEMINARS & WEBINARS: Industry Standards

May 5-9, 2024 Auditing Your Laboratory to ISO/IEC 17025:2017. Virtual. A2LA WorkPlace Training. This ISO/IEC 17025 auditor training course will introduce participants to ISO/IEC 19011, the guideline for auditing management systems as applied to ISO/IEC 17025:2017. https://www.a2lawpt.org/training

May 14-15, 2024 Understanding ISO/IEC 17025:2017 for Testing & Calibration Laboratories. Frederick, MD. A2LA WorkPlace Training. This course is a comprehensive review of the philosophies and requirements of ISO/IEC 17025:2017. The participant will gain an understanding of conformity assessment using the risks and opportunities-based approach. https://www.a2lawpt.org/training

May 22-23, 2024 3004 Understanding ISO/IEC 17025 for Testing and Calibration Labs. Online for Middle-East & South Asia. This Training Course applies to testing and calibration laboratories and regulatory agencies seeking to specify 17025 within their policies and regulations. https://www.iasonline.org/training/ias-training-schedule/

Jun 4-5, 2024 Auditing Your Laboratory to ISO/IEC 17025:2017. Frederick, MD. A2LA WorkPlace Training. This ISO/IEC 17025 auditor training course will introduce participants to ISO/IEC 19011, the guideline for auditing management systems as applied to ISO/IEC 17025:2017. https://www.a2lawpt.org/training

Jun 4-5, 2024 Understanding ISO/IEC 17025 for Testing and Calibration Labs. Online for the Americas. IAS. This 2-day Training Course examines structural components of the standard. Quality system and technical requirements are grouped in a manner that makes them clear and understandable. https://www.iasonline.org/training/ias-training-schedule/

Jun 11-12, 2024 Laboratories: Understanding the Requirements and Concepts of ISO/IEC 17025:2017. Live Online. ANAB. Understand requirements of ISO/IEC 17025:2017, including general, structural, resource, process, and management system requirements. Learn practical concepts, such as impartiality, documents control, ensuring validity of results and risk management. Gain an understanding of an ISO/IEC 17025:2017 laboratory management system. https://anab.ansi.org/training

Jun 11-12, 2024 Internal Auditing for all Standards. Online for the Middle-East and South Asia. IAS. This 2-day Training Course examines auditing principles and techniques and facilitates the practice of required internal audit skills. It is based on internationally-recognized approaches to conducting conformant internal audits. https://www.iasonline.org/training/ias-training-schedule/

Jun 11-13, 2024 Internal Training to ISO/IEC 17025:2017 (Non-Forensic). Live Online. ANAB. This training is designed for laboratory managers, technical staff, and others who want or need to learn better audit practices. https://anab.ansi.org/training

Jun 11-14, 2024 Understanding ISO/IEC 17025:2017 for Testing & Calibration Laboratories. Virtual. A2LA WorkPlace Training. This course is a comprehensive review of the philosophies and requirements of ISO/IEC 17025:2017. The participant will gain an understanding of conformity assessment using the risks and opportunities-based approach. https://www.a2lawpt.org/training

Jun 25-26, 2024 3004 Understanding ISO/IEC 17025 for Testing and Calibration Labs. Online for the Americas. This Training Course applies to testing and calibration laboratories and regulatory agencies seeking to specify 17025 within their policies and regulations. https://www.iasonline.org/training/ias-training-schedule/

Jun 25-26, 2024 Auditing Your Laboratory to ISO/IEC 17025:2017. Virtual. A2LA WorkPlace Training. This ISO/IEC 17025 auditor training course will introduce participants to ISO/IEC 19011, the guideline for auditing management systems as applied to ISO/IEC 17025:2017. https://www.a2lawpt.org/training

Jul 9-10, 2024 Understanding ISO/IEC 17025:2017 for Testing & Calibration Laboratories. Virtual. A2LA

WorkPlace Training. This course is a comprehensive review of the philosophies and requirements of ISO/IEC 17025:2017. The participant will gain an understanding of conformity assessment using the risks and opportunities-based approach. https://www.a2lawpt.org/training

Jul 22-25, 2024 Auditing Your Laboratory to ISO/IEC 17025:2017. Virtual. A2LA WorkPlace Training. This ISO/IEC 17025 auditor training course will introduce participants to ISO/IEC 19011, the guideline for auditing management systems as applied to ISO/IEC 17025:2017. https://www.a2lawpt.org/training

Aug 6-7, 2024 3004 Understanding ISO/IEC 17025 for Testing and Calibration Labs. Online for the Americas. This Training Course applies to testing and calibration laboratories and regulatory agencies seeking to specify 17025 within their policies and regulations. https://www.iasonline.org/training/ias-training-schedule/

Sep 17-18, 2024 Laboratories: Understanding the Requirements and Concepts of ISO/IEC 17025:2017. Live Online. ANAB. Understand requirements of ISO/IEC 17025:2017, including general, structural, resource, process, and management system requirements. Learn practical concepts, such as impartiality, documents control, ensuring validity of results and risk management. Gain an understanding of an ISO/IEC 17025:2017 laboratory management system. https://anab.ansi.org/training

Sep 17-19, 2024 Internal Training to ISO/IEC 17025:2017 (Non-Forensic). Live Online. ANAB. This training is designed for laboratory managers, technical staff, and others who want or need to learn better audit practices. https://anab.ansi.org/training

Oct 8-9, 2024 3004 Understanding ISO/IEC 17025 for Testing and Calibration Labs. Online for the Americas. This Training Course applies to testing and calibration laboratories and regulatory agencies seeking to specify 17025 within their policies and regulations. https://www.iasonline.org/training/ias-training-schedule/

Nov 5-6, 2024 Laboratories: Understanding the

Requirements and Concepts of ISO/IEC 17025:2017. Live Online. ANAB. Understand requirements of ISO/IEC 17025:2017, including general, structural, resource, process, and management system requirements. Learn practical concepts, such as impartiality, documents control, ensuring validity of results and risk management. Gain an understanding of an ISO/IEC 17025:2017 laboratory management system. https://anab.ansi.org/training

Nov 5-7, 2024 Internal Training to ISO/IEC 17025:2017 (Non-Forensic). Live Online. ANAB. This training is designed for laboratory managers, technical staff, and others who want or need to learn better audit practices. https://anab.ansi.org/training

Nov 12-13, 2024 3004 Understanding ISO/IEC 17025 for Testing and Calibration Labs. Online for the Middle-East & South Asia time zone. IAS. This Training Course applies to testing and calibration laboratories and regulatory agencies seeking to specify 17025 within their policies and regulations. https://www.iasonline.org/training/ias-training-schedule/

SEMINARS & WEBINARS: Mass

Jun 3-7, 2024 Mass Metrology Course for High Accuracy: OIML class F to E. Pretoria, South Africa. NMISA. The course provides fundamentals of mass measurements, looking at what affects reliability and accuracy of mass measurements, and how to ensure traceability in weighing. https://store.nmisa.org/collections/face-to-face-courses

Aug 5-16, 2024 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/owm/owm-training-and-events

Oct 21-Nov 1, 2024 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/owm/owm-training-and-events

SEMINARS & WEBINARS: Measurement Uncertainty

May 21-29, 2024 Understanding ISO/IEC 17025:2017. Pretoria, South Africa. NMISA. The course presents an overview of the requirements of ISO/IEC 17025-2017 for the competence of calibration and testing laboratories. This course will equip you with the competence to plan the implementation of ISO/IEC 17025:2017 in a testing or calibration laboratory. https://store.nmisa.org/collections/face-to-face-courses

Jun 17-18, 2024 Measurement Confidence: Fundamentals. Live Online. ANAB. This Measurement Confidence course introduces the foundational concepts of measurement traceability, measurement assurance, and measurement uncertainty and details ISO/IEC 17025 and ISO/IEC 17020 requirements. https://anab.ansi.org/training/measurement-confidence-fundamentals/

Jun 19-20, 2024 Measurement Uncertainty: Practical Applications. Live Online. ANAB. This class covers concepts and accreditation requirements associated with measurement traceability, measurement assurance, and measurement uncertainty. https://anab.ansi.org/training/

Jul 9, 2024 Introduction to Measurement Uncertainty. Frederick, MD. A2LA WorkPlace Training. This course is a suitable introduction for both calibration and testing laboratory participants, focusing on the concepts and mathematics of the measurement uncertainty evaluation process. https://www.a2lawpt.org/training

Jul 10-11, 2024 Applied Measurement Uncertainty for Calibration Laboratories. Denver, CO. A2LA WorkPlace Training. During this course, the participant will be introduced to several tools and techniques that can be applied in the calibration laboratory environment to efficiently and effectively create measurement uncertainty budgets which comply with ISO/IEC 17025 requirements. https://www.a2lawpt.org/training

Aug 5-7, 2024 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

Sep 16-17, 2024 Measurement Confidence: Fundamentals. Live Online. ANAB. This Measurement Confidence course introduces the foundational concepts of measurement traceability, measurement assurance, and measurement uncertainty and details ISO/IEC 17025 and ISO/IEC 17020 requirements. https://anab.ansi.org/training/measurement-confidence-fundamentals/

Sep 18-19, 2024 Measurement Uncertainty: Practical Applications. Live Online. ANAB. This class covers concepts and accreditation requirements associated with measurement traceability, measurement assurance, and measurement uncertainty. https://anab.ansi.org/training/

Oct 2-3, 2024 3006 Uncertainty of Measurement for Labs. Online for Middle-East & South Asia time zone. 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/ias-training-schedule/

Oct 29-31, 2024 Measurement Uncertainty – Fundamentals and Application. Aurora, IL. Mitutoyo. EDU-210 is firmly rooted in national and international standards in terminology and uncertainty. The course follows the concepts from ISO/IEC Guide 98-3 (GUM), which is the required standard for almost all uncertainty evaluations, including labs accredited to ISO/IEC 17025. This course also introduces the powerful concepts of test uncertainty (ISO 14253-5) for the evaluation of measurement uncertainty in the calibration of measuring instruments. https://www.mitutoyo.com/training-education/classroom/

Dec 9-10, 2024 Measurement Confidence: Fundamentals. Live Online. ANAB. This Measurement Confidence course

introduces the foundational concepts of measurement traceability, measurement assurance, and measurement uncertainty and details ISO/IEC 17025 and ISO/IEC 17020 requirements. https://anab.ansi.org/training/measurement-confidence-fundamentals/

SEMINARS & WEBINARS: Pressure

Jun 19-20, 2024 Pressure Measurement. Port Melbourne, VIC. Australian NMI. This two-day course (9 am to 5 pm each day) covers essential knowledge of the calibration and use of a wide range of pressure measuring instruments, their principles of operation and potential sources of error — it incorporates extensive hands-on practical exercises. https://shop.measurement.gov.au/collections/physical-metrology-training

Oct 7-11, 2024 Principles of Pressure Calibration. Phoenix, AZ. Fluke Calibration. A five-day training course on the principles and practices of pressure calibration using digital pressure calibrators and piston gauges (pressure balances).The class is designed to focus on the practical considerations of pressure calibrations. https://us.flukecal.com/training

SEMINARS & WEBINARS: RF & Microwave

Sep 23-27, 2024 RF & Microwave Metrology Fundamentals. Pretoria, South Africa. NMISA. This course is aimed at teaching theoretical and practical principles of measurements and calibrations in RF and Microwave Metrology. Overviews of various instrumentation used for the measurements and calibrations will also be discussed. https://store.nmisa.org/collections/face-to-face-courses

SEMINARS & WEBINARS: Software

May 28-30, 2024 VNA Tools Training Course. Berne-Wabern, Switzerland. Federal Institute of Metrology METAS. VNA Tools is free software developed by METAS for measurements with the Vector Network Analyzer (VNA). The software facilitates the tasks of evaluating measurement uncertainty in compliance with the ISO-GUM and vindicating metrological traceability. The 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

Jul 15-19, 2024 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

Sep 9-13, 2024 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

Oct 7-11, 2024 Advanced MET/CAL® Procedure Writing. Everett, WA. Fluke Calibration. A five-day procedure writing course for advanced users of MET/CAL calibrations software. Prerequisites Note: This course covers advanced topics and requires an existing knowledge of MET/CAL calibration software. https://us.flukecal.com/training

Oct 21-25, 2024 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. You will learn a systematic approach to collect the information you need to manage your lab assets routinely, consistently and completely. https://us.flukecal.com/training

Oct 29-31, 2024 VNA Tools Training Course. Berne-Wabern, Switzerland. Federal Institute of Metrology METAS. VNA Tools is free software developed by METAS for measurements with the Vector Network Analyzer (VNA). The software facilitates the tasks of evaluating measurement uncertainty in compliance with the ISO-GUM and vindicating metrological traceability. The 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

Nov 18-22, 2024 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

SEMINARS & WEBINARS:
Temperature & Humidity

Aug 19-23, 2024 Non-Contact Thermometry Metrology. Pretoria, South Africa. NMISA. The objective of this course is to teach the basic principle of infrared thermometers, the physics behind its operation, method of calibration and traceability. https://store.nmisa.org/collections/face-to-face-courses

CALENDAR

Aug 27-29, 2024 Temperature Measurement. Sydney, Australia. National Measurement Institute. 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

Aug 30, 2024 Liquid-In-Glass Thermometry. Sydney, Australia. National Measurement Institute, Australia. This one-day course will provide calibration and quality control technicians with the skills required to calibrate liquid-in-glass thermometers in accordance with NATA and 17025 requirements. https://shop.measurement.gov.au/collections/physical-metrology-training

Sep 16-18, 2024 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

Oct 7-9, 2024 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: Validation & Verification

May 29, 2024 Validation and Verification of Analytical Methods. Live Online. ANAB. This course provides an introduction to validation and verification of analytical methods and ISO/IEC 17025 & ISO/IEC 17020 requirements. https://anab.ansi.org/training-course-schedule/

Aug 6, 2024 Validation and Verification of Analytical Methods. Live Online. ANAB. This course provides an introduction to validation and verification of analytical methods and ISO/IEC 17025 & ISO/IEC 17020 requirements. https://anab.ansi.org/training-course-schedule/

Oct 9, 2024 Validation and Verification of Analytical Methods. Live Online. ANAB. This course provides an introduction to validation and verification of analytical methods and ISO/IEC 17025 & ISO/IEC 17020 requirements. https://anab.ansi.org/training-course-schedule/

Oct 14-16, 2024 Method Validation. Pretoria, South Africa. NMISA. The objective of this course is to introduce analysts to the basic concepts of method validation and quality control. https://store.nmisa.org/collections/face-to-face-courses

Nov 19, 2024 Validation and Verification of Analytical Methods. Live Online. ANAB. This course provides an introduction to validation and verification of analytical methods and ISO/IEC 17025 & ISO/IEC 17020 requirements. https://anab.ansi.org/training-course-schedule/

SEMINARS & WEBINARS: Volume

Jul 22-25, 2024 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/owm/owm-training-and-events

Aug 5-9, 2024 Volume Metrology. Pretoria, South Africa. NMISA. The course provides fundamentals of volume determination using the gravimetric method, which is the standard method used by NMIs and accredited laboratories to calibrate volumetric standards. https://store.nmisa.org/collections/face-to-face-courses

SEMINARS & WEBINARS: Weight

Nov 4-7, 2024 5853 Balance and Scale Calibration and Uncertainties. NIST. Gaithersburg, MD. This 4-day seminar will cover the calibration and use of analytical weighing instruments (balances and laboratory/bench-top scales), including sources of weighing errors in analytical environments, methodologies for quantifying the errors, and computation of balance calibration uncertainty and global (user) uncertainty. https://www.nist.gov/pml/owm/training

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Researchers Develop a New Type of Frequency Comb that Promises to Further Boost the Accuracy of Time Keeping

New device can measure the frequencies of light over a previously inaccessible range.

March 14, 2024, NIST News – Chip-based devices known as frequency combs, which measure the frequency of light waves with unparalleled precision, have revolutionized time keeping, the detection of planets outside of our solar system and high-speed optical communication.

Now, scientists at the National Institute of Standards and Technology (NIST) and their collaborators have developed a new way of creating the combs that promises to boost their already exquisite accuracy and allow them to measure light over a range of frequencies that was previously inaccessible. The extended range will enable frequency combs to probe cells and other biological material.

The new devices, which are fabricated on a small glass chip, operate in a fundamentally different way from previous chip-based frequency combs, also known as microcombs.

A frequency comb acts as a ruler for light. Just as the uniformly-spaced tick marks on an ordinary ruler measure the length of objects, the uniformly-spaced frequency spikes on a microcomb measure the oscillations, or frequencies, of light waves.

Researchers typically employ three elements to build a microcomb: a single laser, known as the pump laser; a tiny ring-shaped resonator, the most important element; and a miniature waveguide that transports light between the two. Laser light that's injected into the waveguide enters the resonator and races around the ring. By carefully adjusting the frequency of the laser, the light within the ring can become a soliton—a solitary wave pulse that preserves its shape as it moves.

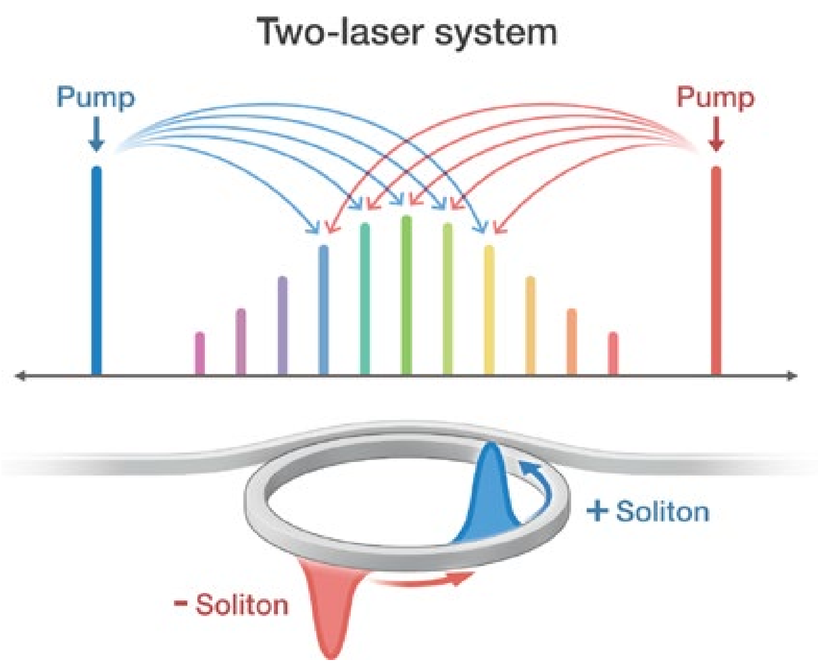
Each time the soliton completes one round trip around the ring, a portion of the pulse splits off and enters the waveguide. Soon, an entire train of the narrow pulses, which resemble spikes, fills the waveguide, with each spike separated in time by the same fixed interval—the time it took for the soliton to complete one lap. The spikes correspond to a single set of evenly spaced frequencies and form the tick marks, or "teeth," of the frequency comb.

This method of generating a microcomb, though effective, can only produce combs with a range of frequencies centered on the frequency of the pump laser. To overcome that limitation, NIST researchers Grégory Moille and Kartik Srinivasan, working with an international team of researchers led by Miro Erkintalo of the University of Auckland in New Zealand and the Dodd-Walls Centre for Photonic and Quantum Technologies (https://www.doddwalls.ac.nz/), theoretically predicted and then experimentally demonstrated a new process for producing a soliton microcomb. Instead of employing a single laser, the new method uses two pump lasers, each of which emits light at a different frequency. The complex interaction between the two frequencies produces a soliton whose central frequency lies exactly in between the two laser colors.

The method allows scientists to generate combs with novel properties in a frequency range that is no longer limited by pump lasers. By generating combs that span a different set of frequencies than the injected pump laser, the devices could, for example, allow scientists to study the composition of biological compounds.

Beyond this practical advantage, the physics that underlies this new type of microcomb, known as a parametrically-driven microcomb, may lead to other important advances. One example is a potential improvement in the noise associated with the individual teeth of the microcomb.

In a comb generated by a single laser, the pump laser directly sculpts only the central tooth. As a result, the teeth become wider the farther they lie from the center of the comb. That's not desirable, because wider teeth can't measure frequencies as precisely as narrower ones.



In the new comb system, two pump lasers shape each tooth, producing a frequency comb that could theoretically be sharper than a comb produced by a single laser. Bottom: The interaction between the two lasers randomly produces solitons in two different phases, which can be understood as a soliton pulse having either a positive or negative sign. Credit: S. Kelley/NIST.

In the new comb system, the two pump lasers shape each tooth. According to theory, that should produce a set of teeth that are all equally narrow, improving the accuracy of measurements. The researchers are now testing whether this theoretical prediction holds true for the microcombs they have fabricated.

The two-laser system offers another potential advantage: It produces solitons that come in two varieties, which can be likened to having either a positive or negative sign. Whether a particular soliton is negative or positive is purely random because it arises from the quantum properties of the interaction between the two lasers. This may enable the solitons to form a perfect random number generator, which plays a key role in creating secure cryptographic codes and in solving some statistical and quantum problems that would otherwise be impossible to solve with an ordinary, non-quantum computer.

The researchers described their work online in the March 14 issue of *Nature Photonics* (https://www.nature.com/articles/s41566-024-01401-6).[1] The team includes François Leo and his colleagues from the Université Libre de Bruxelles, Belgium, Julien Fatome of the Université de Bourgogne in Dijon, France, and scientists from the Joint Quantum Institute, a research partnership between NIST and the University of Maryland.

Source: https://www.nist.gov/news-events/news/2024/03/researchers-develop-new-type-frequency-comb-promises-further-boost-accuracy

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1 Paper: G. Moille, M. Leonhardt , D. Paligora, N. Englebert, F. Leo, J. Fatome, K. Srinivasan, and M. Erkintalo. Parametrically driven pure-Kerr temporal solitons in a chip-integrated microcavity. *Nature Photonics*, posted online March 14, 2024. DOI: https://doi.org/10.1038/s41566-024-01401-6

Calibrations Are Going Digital

The digital accreditation symbol and digital calibration certificate are ready to be put into practice

PTB-News 1.2024 — Following a successful pilot phase, accredited calibration laboratories will be able to apply for the digital calibration symbol starting in late March 2024 and thus provide digital proof that they are accredited. In combination with the digital calibration certificate developed by PTB, it serves as machine readable, tamper-proof and verifiable evidence of calibration which will ultimately replace paper calibration certificates.

Industry 4.0 requires rapid, smooth and fail-safe communication between all participating machines. The successful calibration of a measuring instrument by an accredited body must also find its place in the digital communication chain. Two decisive elements of the certificate have been transferred to a digital format and brought to maturity: proof that the calibration body has been accredited by DAkkS (the digital accreditation symbol) and proof that the measuring instrument has been calibrated. The latter is PTB's digital calibration certificate (DCC). These elements needed to be combined before fully automated processing, or "eAttestation," could be achieved.

eAttestation underwent testing for several months. The participating pilot companies rated it as "fast, simple and useful." It is therefore now time to put eAttestation into real practice: Accredited bodies can apply for the digital accreditation symbol from DAkkS starting on 30 March 2024.

The digital accreditation symbol is based on an electronic seal which is like a company stamp with additional accreditation information. It provides proof of accreditation in the digital realm. Accordingly, the digital calibration certificate enables calibration results to be transferred in a correct, fail-safe and machine-readable manner. On the basis of this, it will be possible to realize automated and networked production processes and their quality assurance in the future, which will increase efficiency and reduce costs.

Combining PTB's digital calibration certificate (DCC) with DAkkS's accreditation symbol contributes to widely automating production processes. Credit: PTB

PTB and the German Calibration Service (DKD) will continue to harmonize the contents of the DCC. In doing so, the DKD's expert committees are contributing to making the quality assurance behind "Made in Germany" more widely known and successfully applicable in an international context.

The project is an important element of the "QI-Digital" initiative in which DAkkS and PTB are working on viable digital solutions in the different areas of QI: metrology, standardization, accreditations, conformity assessments and market surveillance together with the BAM Federal Institute for Materials Research and Testing, the German Institute for Standardization (DIN) and the German Commission for Electrical, Electronic & Information Technologies (DKE).

The QI-Digital homepage: www.qi-digital.de

Source: https://www.ptb.de/cms/en/presseaktuelles/journals-magazines/ptb-news.html

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World Metrology Day - 20 May 2024

We measure today for a sustainable tomorrow

BIPM and OIML — 20 May is World Metrology Day, commemorating the anniversary of the signing of the Metre Convention in Paris, in 1875. This treaty provides the basis for a worldwide coherent measurement system that underpins scientific discovery and innovation, industrial manufacturing and international trade, as well as the improvement of the quality of life and the protection of the global environment.

The theme for World Metrology Day 2024 is Sustainability, chosen for its relevance to various measurement opportunities crucial for fostering a sustainable global economy and environment. Examples include measuring energy use in industries, buildings and transportation, managing resources in agriculture and forestry, identifying pollution sources, and setting targets for environmental protection. Accurate measurements of vehicle emissions and fuel consumption are vital for regulatory compliance and designing sustainable transportation options. The assessment and management of manufacturing processes and waste streams, facilitated by accurate measurements, contribute to improved environmental stewardship.

Across the world, national metrology laboratories continually advance measurement science by developing and validating new measurement techniques at the necessary level of sophistication. The national metrology institutes participate in measurement comparisons coordinated by the Bureau International des Poids et Mesures (BIPM) or by the Regional Metrology Organizations, to ensure the reliability of measurement results worldwide.

The International Organization of Legal Metrology (OIML) develops International Recommendations, which aim to align and harmonize requirements worldwide in many fields. The OIML also operates the OIML Certification System (OIML-CS) which facilitates international acceptance and global trade of regulated measuring instruments.

These international metrology systems provide the necessary assurance and confidence that measurements are accurate, providing a sound basis for global trade today and helping us to prepare for the challenges of tomorrow.

World Metrology Day acknowledges and honors the contributions of individuals working in intergovernmental, regional, and national metrology organizations and institutes year-round. In November 2023, a significant milestone was reached as the UNESCO General Conference, during its 42nd Session, officially recognized the celebration on 20 May annually. Underscoring its pivotal role in advancing global scientific cooperation, this endorsement opens up new avenues to promote metrology, aligning with UNESCO's mission to build a better world through science and education.

Further information, including a message from the Directors, posters, and a list of events, is available at www.worldmetrologyday.org – Contact: wmd@worldmetrologyday.org

World Metrology Day is an annual event during which the impact of measurement on our daily lives is celebrated around the world. This date was chosen in recognition of the signing of the Metre Convention on 20 May 1875, the beginning of formal international collaboration in metrology. Each year World Metrology Day is organized and celebrated jointly by the International Bureau of Weights and Measures (BIPM) and the International Organization of Legal Metrology (OIML) with the participation of the national organizations responsible for metrology.

Source: https://www.worldmetrologyday.org/press_release.html

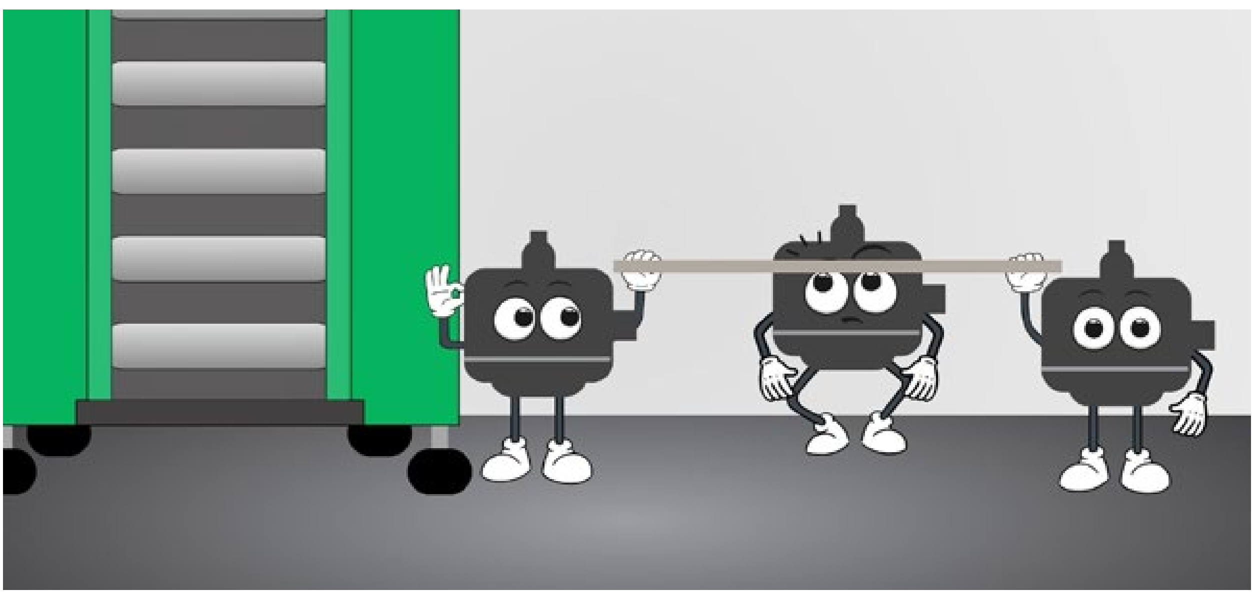
CAL-TOONS by Ted Green teddytoons@icloud.com

How Low Can My Load Cell Go?

Henry Zumbrun
Morehouse Instrument Company

Load cells are subject to numerous factors that can affect their performance. Some factors include the design of the load cell, the readout used with the load cell, environmental conditions, cable length (if only a four-wire cable is used), overloading, adapters, stability, alignment, and the test method. There are enough load cell intricacies that impact measurement uncertainties to write a book strictly on that subject, which we have already done [1].

Management often wants to spend the least on equipment and push equipment such as load cells to their lowest operational level. Who can blame them as who would not want less equipment with better performance? Using equipment such as load cells below 5 – 10 % of their capacity or lower, such as 2 %, is a frequent practice that demands attention as it can significantly impact measurement uncertainty as a percentage of applied force. This article examines the impact on measurement uncertainty of using a load cell as low as 2 % of its rated capacity, compliance with ISO 376 and ASTM E74 lowest force point criteria, and how to uphold the reliability necessary to maintain a specific calibration interval. What holds for these standards can apply to any load cell.



Introduction

Many customers ask, "How low can my load cell go?" We understand the potential benefits of using a load cell from 2 % to 100 % of its capacity.

Benefits like the lower your load cell can go to measure forces, the less equipment one would need to carry, and the fewer setups one would need to make; sometimes, fewer calibration costs would occur, and who would not want any of these things?

So, how low can your load cell go? Like the Limbo, everything has a point where going lower is impossible. In this article, we provide three things to consider in regards to measurement uncertainty when you ask how low my load cell can go.

We assume that one has communicated clearly with their calibration provider how they use the load cell so that the calibration lab can best replicate use. That means whatever readout is being used, adapters, cables, and standards or procedures being followed are sent in and communicated to the calibration laboratory.

Consideration #1: What is the impact on measurement uncertainty for using a load cell as low as 2 % of its rated capacity?

Often the most significant contributions to MU (Measurement Uncertainty) would be the resolution, stability of the instrument, ASTM LLF (Lower Limit Factor) if applicable, and the reference standard uncertainty used to perform the calibration.

Resolution

Resolution is the smallest change in the measured quantity that causes a detectable change in the corresponding indication. Resolution is found by taking the output of the load cell / by the indicated reading at capacity, and then that number is multiplied by the readability.

Case # 1: In mV/V At 25,000, a load cell typically has an output of 2 – 4 mV/V. Most meters will read up to the 5th decimal place. Thus, 25,000 / 4.00000 = 6250, which we multiply by the readability of 0.00001 = 0.0625.

Case # 2: In force units, a 25,000-load cell may count by 1; there would be 25,000/25,000 = 1, then multiply by 1 = 1.

Comparing Case # 1 at the 2 % force pt, our MU (Measurement Uncertainty) is 0.47 or 0.094 %, and in Case # 2, 0.74 or 0.149 % by only changing the reference resolution from 0.0625 to 1. More on the complete MU budget later.

Reference Standard Stability

Typically, Reference Standard Stability is defined as the change from one calibration to the next. Morehouse wrote a paper on Load Cell Reliability that goes into much more detail on the reliability of load cells: https://mhforce.com/wp-content/uploads/2023/09/Morehouse-Load-Cell-Reliability-1.pdf.

The conclusion was that selecting the load cell and meter is pivotal, if someone wants to maintain an overall reliability of 95 % with 95 % confidence of 0.05 % or better.

In our sampling, we did not look at data below 10 % of a load cell capacity, as the population data showed the very best systems to have a 95 % confidence that the process was at least 89.33 % reliable at 10 % of capacity; the numbers would have been much worse below that number.

For our example, we will assume an exceptionally good load cell, like a shear web type with a base and threaded adapter installed, paired with a higher-end meter like the 4215 HS. Typical stability might be around 0.1 % at 1 % capacity and 0.05 % at 2 %.

ASTM Lower Limit Factor

ASTM LLF, or Lower Limit Factor, is a statistical estimate of the error in forces computed from the calibration equation of a force-measuring instrument when the instrument is calibrated following ASTM E74 standard practice for calibration and verification for force-measuring instruments [2].

The ASTM LLF quantifies the Reproducibility Condition of the calibrated device by following the ASTM E74 standard. More information on the ASTM LLF can be found at https://mhforce.com/lower-limit-factor-improve-calibration-accuracy/.

For our example, the ASTM LLF is 0.209.

Reference Standard Uncertainty

This is the uncertainty of the reference standard used to calibrate the load cell.

Note: If the calibration was not done following ASTM E74, one might use the load cell specifications or values from the calibration certificate, which could include non-linearity, repeatability, and, if making descending measurements, hysteresis.

Case # 1: Primary Standards (Deadweights) are used to calibrate the load cell within 0.0016 %.

In Case # 1, our MU cannot be less than the standard used to calibrate the device. Thus, our MU cannot be less than 0.0016 % of the applied force.

Case # 2: Secondary Standards (those calibrated by deadweight) are used to calibrate the load cell. The typical number for a secondary standard varies between 0.02 – 0.05 %; we will use 0.035 % for comparison.

In Case # 2, our MU cannot be less than the standard used to calibrate the device. Thus, our MU cannot be less than 0.035 % of the applied force.

Note: The deadweight primary standard provides the best possible calibration on How Low Can my Load Cell Go.

The following Measurement Uncertainty Budgets only include information available to Morehouse and are incomplete as environmental conditions during use, repeatability studies, repeatability and reproducibility between operators, resolution of the

Measurement Uncertainty Budget Worksheet									
Laboratory	Morehouse								
Parameter	FORCE	Range	25000	Sub-Range	2 % Force Point				
Technician	HZ	Standards Used	SAMPLE LOAD CELL FOR HOW LOW CAN MY LOAD CELL GO						
Date	12.28.2023								
Uncertainty Contributor	Magnitude	Type	Distribution	Divisor	df	Std. Uncert	Variance (Std. Uncert^2)	% Contribution	
ASTM E74 LLF	87.0833E-3	A	Normal	1.000	32	87.08E-3	7.58E-3	13.85%	
Environmental Conditions	7.5000E-3	B	Rectangular	1.732	200	4.33E-3	18.75E-6	0.03%	
Stability of Ref Standard	375.0000E-3	B	Rectangular	1.732	200	216.51E-3	46.88E-3	85.58%	
Ref Standard Resolution	58.0000E-3	B	Resolution	3.464	200	16.74E-3	280.33E-6	0.51%	
Morehouse CMC (Ref Lab)	8.0000E-3	B	Expanded (95.45% k=2)	2.000		4.00E-3	16.00E-6	0.03%	
			Combined Uncertainty (u_c)=			234.04E-3	54.77E-3	100.00%	
			Effective Degrees of Freedom			234			
			Coverage Factor (k), Confidence Interval =	95.45%		2.01			
			Expanded Uncertainty (U) K =			0.47	0.09412%		

Figure 1. How Low Can My Load Cell Go 2 % of Capacity Incomplete MU Budget.

best existing device, and other error sources are not included.

For the sake of this article, these examples would be the absolute best one could achieve using the Welch-Satterthwaite equation, and their overall MU would be much higher with more contributions to MU than shown here.

When we look at the overall measurement uncertainty of the 2 % force point at the time of calibration, the dominant contribution is the stability of the reference standard in this example.

We typically see either the ASTM LLF or the reference standard stability as a dominant contributor to the overall MU. Occasionally, one will set the resolution too coarse, and that will become dominant. When we look at the overall measurement uncertainty of the 1 % force point at the time of calibration, the dominant contribution is the stability of the reference standard in this example.

Note: We use some best-case scenarios for stability and the ASTM LLF.

On how low my load cell will go, the comparison between a 2 % and 1 % force point percentage-wise shows that at the 1 % force point, the overall MU is 0.136 % versus 0.094 % of applied force at the 2 % point.

If the ASTM LLF factor was dominant, there are options such as having the load cell calibrated using its normal range and then calibrating a separate low range. The ASTM LLF is often lower at a low-range calibration when compared to the normal calibration.

The stability, resolution, and reference standard uncertainty typically remain constant; thus, only certain load cells can be used with multiple ranges. In some cases, a second range from 1 % - 10 % of capacity might work, some 2 % - 20 % of capacity might work, and in others, a second range would have minimum benefit, if any. To know what may work, contact your calibration provider.

Measurement Uncertainty Budget Worksheet								
Laboratory	Morehouse							
Parameter	FORCE	Range	25000	Sub-Range	1 % Force Point			
Technician	HZ	Standards Used	SAMPLE LOAD CELL FOR HOW LOW CAN MY LOAD CELL GO					
Date	12.28.2023							
Uncertainty Contributor	Magnitude	Type	Distribution	Divisor	df	Std. Uncert	Variance (Std. Uncert^2)	% Contribution
ASTM E74 LLF	87.0833E-3	A	Normal	1.000	32	87.08E-3	7.58E-3	26.42%
Resolution of UUT	000.0000E+0	B	Resolution	3.464	200	000.00E+0	000.00E+0	0.00%
Environmental Conditions	3.7500E-3	B	Rectangular	1.732	200	2.17E-3	4.69E-6	0.02%
Stability of Ref Standard	250.0000E-3	B	Rectangular	1.732	200	144.34E-3	20.83E-3	72.58%
Ref Standard Resolution	58.0000E-3	B	Resolution	3.464	200	16.74E-3	280.33E-6	0.98%
Morehouse CMC (Ref Lab)	4.0000E-3	B	Expanded (95.45% k=2)	2.000	200	2.00E-3	4.00E-6	0.01%
			Combined Uncertainty (u_c)=			169.43E-3	28.71E-3	100.00%
			Effective Degrees of Freedom			207		
			Coverage Factor (k), Confidence Interval =	95.45%		2.01		
			Expanded Uncertainty (U) K =			0.34	0.13637%	

Figure 2. How Low Can My Load Cell Go 1 % of Capacity Incomplete MU Budget.

7.3 Minimum force

Taking into consideration the accuracy with which the deflection of the instrument can be read during calibration or during its subsequent use for verifying machines, the minimum force applied to a force-proving instrument shall comply with the two following condition:

a) the minimum force shall be greater than or equal to:

- 4 000 x r for class 00;
- 2 000 x r for class 0,5;
- 1 000 x r for class 1;
- 500 x r for class 2.

b) the minimum force shall be greater than or equal to 0,02 F_f.

Figure 3. How Low Can My Load Cell Go ISO 376 Requirements [3].

Consideration #2: ISO 376 and ASTM E74 lowest force point criteria.

Using a load cell below 2 % of its capacity is not recommended. ISO 376 and ASTM E74 have different criteria for establishing the first usable force point.

ISO 376 section 7.3 requires the minimum force to be greater than or equal to 2 %.

Listed below are ASTM Sections referencing the lowest possible applied force:

- Section 8.6.3.2 Class A—For force-measuring instruments used to verify testing machines in accordance with Practices E4, or similar applications, the LLF of the force-measuring instrument shall not exceed 0.25 % of force. The lower force limit for use over the Class A verified range of forces is 400 times the LLF in force units obtained from the calibration data.
- ASTM E74 Note 8 states, "It is recommended that the lower force limit be not less than 2 % (1/50) of the capacity of the force-measuring instrument [4]."

Consideration #3: ASTM E74 on Calibration Due Dates

One of the main reasons we would advise against using a load cell below 5 % or 2 % is found in section 11.2.1 of the ASTM E74 standard, which states, "Force-measuring instruments shall demonstrate changes in the calibration values over the range of use during the recalibration interval of less than 0.032 % of reading for force-measuring instruments and systems used over the Class AA verified range of forces and less than 0.16 % of reading for those instruments and systems used over the Class A verified range of forces [4]."

Notice we are not considering 1 % as the likelihood of meeting the criteria is low. Some load cells may meet the criteria, though almost any shift in output would cause the instrument not to meet the criteria outlined in section 11.2.1, and the result would be the user no longer being able to have a calibration interval of two years, which would increase downtime and calibration costs.

Conclusion

The question "How low can my load cell go?" involves intricate considerations to maintain a low measurement uncertainty and maintain the reliability one needs to maintain a specific calibration interval.

The assessment of measurement uncertainty, including factors such as resolution, reference standard stability, ASTM LLF or other specifications, when applicable, and the uncertainty of the calibration standard, is vital for understanding the limitations and precision of a load cell at lower force levels. Moreover, adherence to industry standards, such as ASTM E74 and ISO 376, provides clear guidelines and recommendations on the minimum force points for load cell usage.

The implications of calibration due dates, as outlined in ASTM E74, further emphasize the practical challenges associated with using load cells at extremely low force levels.

Meeting calibration criteria becomes critical for maintaining calibration intervals and avoiding increased downtime and calibration costs.

Like people doing the Limbo, each load cell is different—some will be able to go lower than others, and some will fail early.

If you buy great equipment, the chances of maintaining a usable range of 2 % or better with a Measurement uncertainty of under 0.1 % of applied is possible, though not typical.

The decision on how low a load cell can go should be a careful balance between the application's specific requirements, adherence to the appropriate standard, and the practical constraints imposed by calibration considerations.

References

[1] Zumbrun, Henry. *Force Calibration for Technicians and Quality Managers: Top Conditions, Methods, and Systems that Impact Force Calibration Results*, 2022. Available online at https://mhforce.com/force-calibration-for-technicians-ebook-2022-edition/.

[2] ASTM E74 *Standard Practices for Calibration and Verification for Force-Measuring Instruments*, Section 8. Available online at https://www.astm.org/e0074-18e01.html.

[3] ISO 376:2011 *Metallic materials — Calibration of force-proving instruments used for the verification of uniaxial testing machines*, Section 7. Available online at https://www.iso.org/standard/44661.html.

[4] ASTM E74 *Standard Practices for Calibration and Verification for Force-Measuring Instruments*, Section 11. Available online at https://www.astm.org/e0074-18e01.html.

Henry Zumbrun (hzumbrun@mhforce.com), Morehouse Instrument Company, Inc., York, PA 17403, USA.

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Deconvolution-Based Time Response Measurement for Wideband Power Sensors

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Keysight Technologies

In time response tests involving "non-ideal" pulse-modulated signals for wideband power sensor characterization, result correction becomes essential. Traditionally, the Root Sum Square (RSS) calculation is employed for this purpose. However, due to inherent limitations in the RSS method, deconvolution emerges as an alternative for result correction. This paper outlines a fundamental process for obtaining a power sensor's time response using deconvolution. Additionally, we delve into two critical aspects of the deconvolution process: enveloping trace extraction from the incident pulse-modulated signal and effective result denoising.

1. Introduction

The utilization of pulse modulation signals spans a wide range of applications, including Radar [1], communication systems, and biological research. In this context, various instruments play a crucial role in handling pulsed signals. These instruments include oscilloscopes and wideband power sensors.

Characterizing the time response of these instruments is of paramount importance. For instance, state-of-the-art wideband power sensors now exhibit remarkable time response performance, with response times measured in nanoseconds. However, testing such sensors presents a significant challenge due to the inherent edge transitions of the pulsed RF signals generated by signal generators.

Traditionally, the Root Sum Square (RSS) calculation [2] has been employed to correct test results, and this method is well-suited for instruments with a Gaussian response. However, as modern instruments become increasingly digitalized, some no longer adhere to Gaussian behavior. Consequently, relying solely on the traditional RSS calculation may lead to inaccuracies in test result corrections [3].

In this evolving landscape, researchers and engineers must explore alternative approaches to ensure precise characterization of instrument time response. This paper delves into the challenges posed by digitalization and introduces the method of deconvolution for test results correction.

2. Basic of Convolution and Deconvolution

In the realm of signal processing, convolution plays a pivotal role. It represents the process by which one function's shape is modified by another, resulting in a third function. Specifically, the output of convolution yields a new signal that encapsulates the combined effects of both input functions.

Conversely, deconvolution serves as the inverse operation of convolution. Its purpose is to reverse

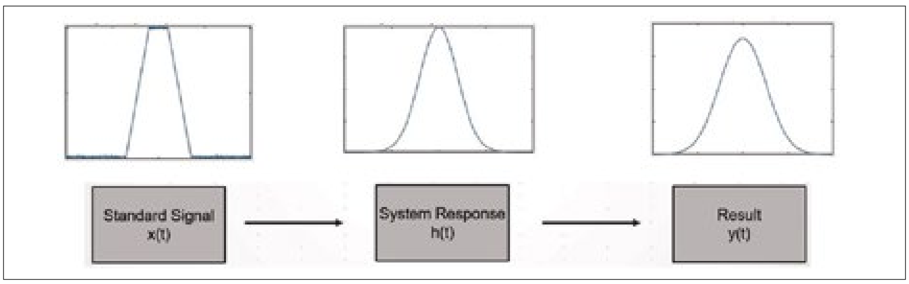

Figure 1. The convolution process of convolving the standard signal and system response

the effects of convolution applied to a given function. Deconvolution proves invaluable in scenarios where filters, blurring, or other distortions have been imposed on a signal.

Consider an example from the field of RF testing, we start with a standard signal denoted as $x(t)$, which traverses a system characterized by a specific response function $h(t)$. The resulting system output, represented by the function $y(t)$, corresponds precisely to the convolution result.

Please see Figure 1, in this scenario, the standard signal exhibits a trapezoidal shape. As it passes through the system with a Gaussian response, the system output $y(t)$ manifests a broader width than the original standard signal or the system response alone.

The above convolution process can be expressed as:

$$y(t) = x(t) * h(t) = \int_{-\infty}^{\infty} x(\tau)\, h(t-\tau)\, d(\tau) \quad (1)$$

The deconvolution stands as the inverse operation of convolution. Essentially, it allows us to recover the original signal or system response from the observed output signal $y(t)$. Given the system output $y(t)$, we can restore the original signal $x(t)$ by deconvolving the system response $h(t)$. Mathematically, this process is expressed as:

$$x(t) = y(t) * h^{-1}(t) \quad (2)$$

where $x(t)$ represents the original signal, $y(t)$ is the observed result, and $h(t)$ denotes the system response.

Conversely, we can also recover the system response $h(t)$ by deconvolving the original signal $x(t)$ from the same output $y(t)$. This process is expressed as:

$$h(t) = y(t) * x^{-1}(t) \quad (3)$$

3. The Result Correction for Gaussian Shape and Non-Gaussian Shape

The traditional root sum square (RSS) calculation has long been employed for assessing system performance in Gaussian environments. However, its applicability is limited to Gaussian cases only. In contrast, the deconvolution method offers a more versatile approach that can be applied to both Gaussian and non-Gaussian scenarios. In this study, we explore the implications of employing the deconvolution method in signal processing for the Gaussian and non-Gaussian scenarios.

Figure 2 illustrates the entire convolution and deconvolution process of the Gaussian scenario, the steps are as the below.

a. Generate an original Gaussian pulse signal denoted as 'z' with a standard deviation (Sigma) of 0.06. The rise time of this signal is 0.159 ms.

b. Create a Gaussian system impulse response, represented as 'h' with a standard deviation of 0.1. The rise time for this impulse response is 0.332 ms.

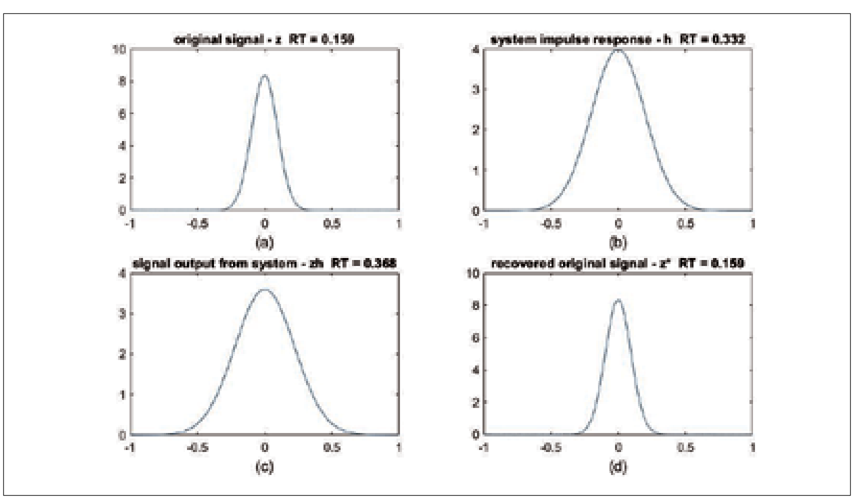

Figure 2. The process of convolving two Gaussian signals and recovering the original signal

c. Perform convolution between the original signal 'z' and the system impulse response 'h' to obtain a new function 'zh.' This function represents the modified signal resulting from the interaction of 'z' with the system response. The rise time of 'zh' is 0.368 ms, accounting for both the original signal and system effects.
d. Deconvolve the system impulse response 'h' from the modified signal 'zh' to retrieve the original signal 'z*.' Remarkably, 'z*' remains identical to the initial 'z,' demonstrating that deconvolution allows signal recovery. The rise time of 'z*' remains at 0.159 ms.

Furthermore, let's try the other method, RSS calculation, then we can get the corrected result by Equation (4):

$$Corrected\_Risetime\_z = \sqrt{Risetime\_zh\text{^}2 - Risetime\_h\text{^}2} = 0.159\ ms \quad (4)$$

The analysis reveals that the rise time of the recovered signal 'z*' obtained through deconvolution matches the corrected rise time of signal 'z.' Consequently, we can confidently assert that both the RSS method and deconvolution yield accurate test results for the Gaussian signal.

Next, we consider a non-Gaussian scenario. The original signal exhibits a trapezoidal shape, while the system impulse response remains Gaussian with a standard deviation of 0.1, consistent with the previous Gaussian case. Deconvolving the system impulse response from the convolution result yields the recovered original signal 'y*.' Refer to Figure 3 for an illustration of the entire process.

Using the RSS calculation, then we can get the corrected result by Equation (5):

$$Corrected\_Risetime\_y = \sqrt{Risetime\_yh\text{^}2 - Risetime\_h\text{^}2} = 0.244\ ms \quad (5)$$

In the above investigation, we consider the rise time of an original signal with a reference value of 0.2 ms. Employing the RSS calculation method, we obtain a corrected rise time result of 0.244 ms. The deviation between these two values amounts to 22%, indicating a non-negligible error.

4. Wideband Power Sensor Time Response Test Based on Deconvolution

High-quality wideband power sensors often exhibit impressive rising edge performance, with response times measured in nanoseconds. To assess the rising edge behavior of such sensors, a common approach involves the following steps:

a. Signal Generation: Utilize an RF signal generator to produce a pulse modulation signal with a fast-rising edge.

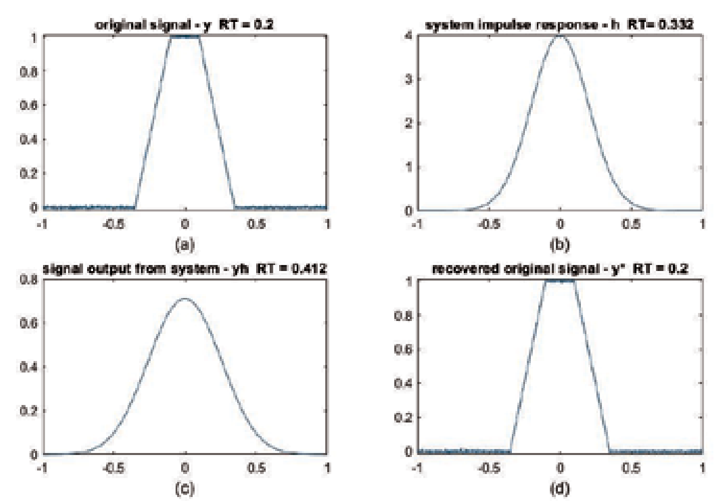

Figure 3. The process of convolving a trapezoidal signal and a Gaussian signal and recovering the original signal

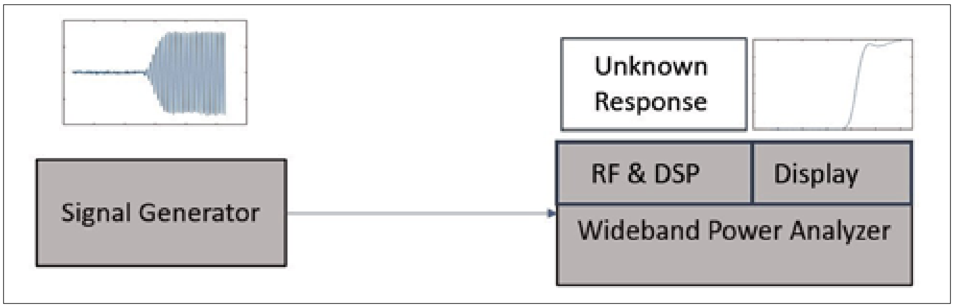

Figure 4. The time response test setup for the wideband power sensor

b. Power Sensor Testing: Feed the generated pulse modulation signal into the power sensor under evaluation.
c. Visualization: The power sensor captures and visualizes the pulse modulation signal. The resulting display provides insights into the sensor's time response performance.

Refer to Figure 4 for a schematic representation of the experimental setup.

For the power sensor system testing, the commonly employed high-class signal source exhibits a rising edge performance on the order of several nanoseconds. However, when dealing with Devices Under Test (DUTs) that share similar performance characteristics as standard equipment, a critical question arises: Can the RSS method yield accurate rise time test results?

The uncertainty stems from the unknown rising edge shapes of both the DUT and standard equipment. If both exhibit Gaussian-shaped rising edges, the RSS method may suffice. However, this assumption is not straightforward to validate.

Fortunately, our investigation into deconvolution provides promising insights. The deconvolution method, as demonstrated by the results, proves effective for time response tests. Moreover, it can handle diverse rising edge shapes, making it a valuable tool in rise-time analysis.

4.1 Pulsed Signal Generation and Envelope Extraction

As mentioned, for testing the power sensor time response, a pulsed signal generator plays a crucial role in generating the pulse modulation signal. The faster the edge of this pulse-modulated signal, the more accurate the assessment. However, in practice, signals are rarely ideal. It becomes essential to characterize these non-ideal edges and mitigate their impact during subsequent deconvolution processes.

The pulsed signal under test is denoted as $x(t)$, and then we express the real-valued signal $x(t)$ as an analytic signal $y(t)$, obtained through the below Hilbert transform [4] :

$$y(t) = y_r(t) + j y_i(t) = x(t) + jH[x(t)] \tag{6}$$

The imaginary component $H[x(t)]$ is the Hilbert transform of $x(t)$, which gives the signal $x(t)$±90° degree.

The envelope value is derived from the analytic signal $x(t)$ as:

$$A_{x(t)} = \sqrt{y_r^2(t) + y_i^2(t)} = \sqrt{x^2(t) + H[x(t)]^2} \tag{7}$$

The rise time of the upper envelope trace is determined by the transition duration between the 10% and 90% reference levels usually [5].

Figure 5 illustrates the envelope traces obtained using filter lengths of 500 and 1000. While the filter length appears to have minimal impact on the rise time of the envelope trace, it significantly affects the deconvolution result in the next step. Specifically, the noise ripple plays a critical role; smaller filter lengths introduce ripples that amplify deconvolved noise.

4.2 Deconvolution Calculation Process

Deconvolution serves as a valuable technique for mitigating non-ideal responses within complex systems[6][7]. By applying deconvolution, we enhance the accuracy of our test results.

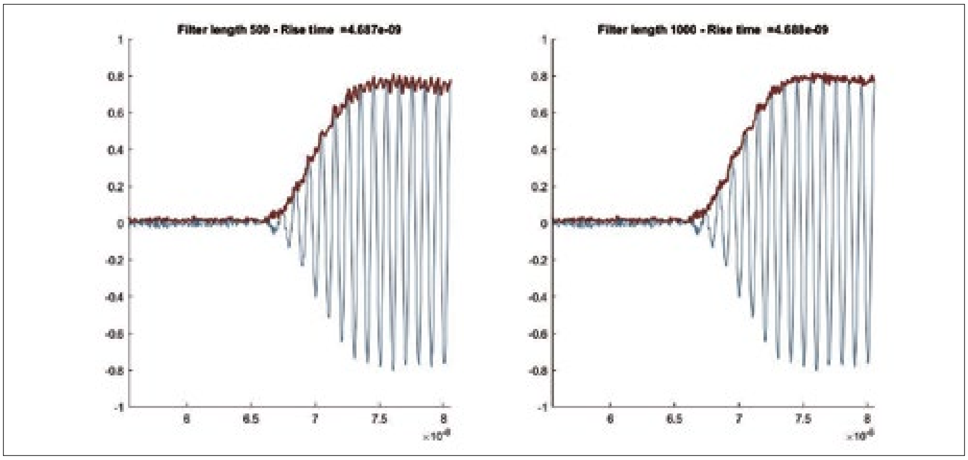

Figure 5. The envelope trace extraction with different filter length

The power sensor system plays a pivotal role in this process. It captures the pulse modulation signal and subsequently displays the pulse modulation signal envelope, along with other characterizations of the pulsed signal.

To address the impact of non-ideal edges introduced by the signal generated from the signal generator, we export the raw result trace for deconvolution calculations. Notably, the power sensor system's sampling rate is lower than the sampling rate setting used for capturing the signal $x(t)$. Therefore, interpolation becomes necessary to reconstruct the result trace and facilitate deconvolution calculations.

The methodology is exporting traces of the pulsed signal and the raw result from an oscilloscope and the DUT, then using these two sets of traces to implement the deconvolution calculation. The entire process is illustrated in Figure 6.

Let us examine the deconvolution results and compare them with the traditional RSS method. The following data points are relevant:

- Original signal rise time is 4.67 ns.
- The signal rise time captured by the power sensor system is 6.62 ns.

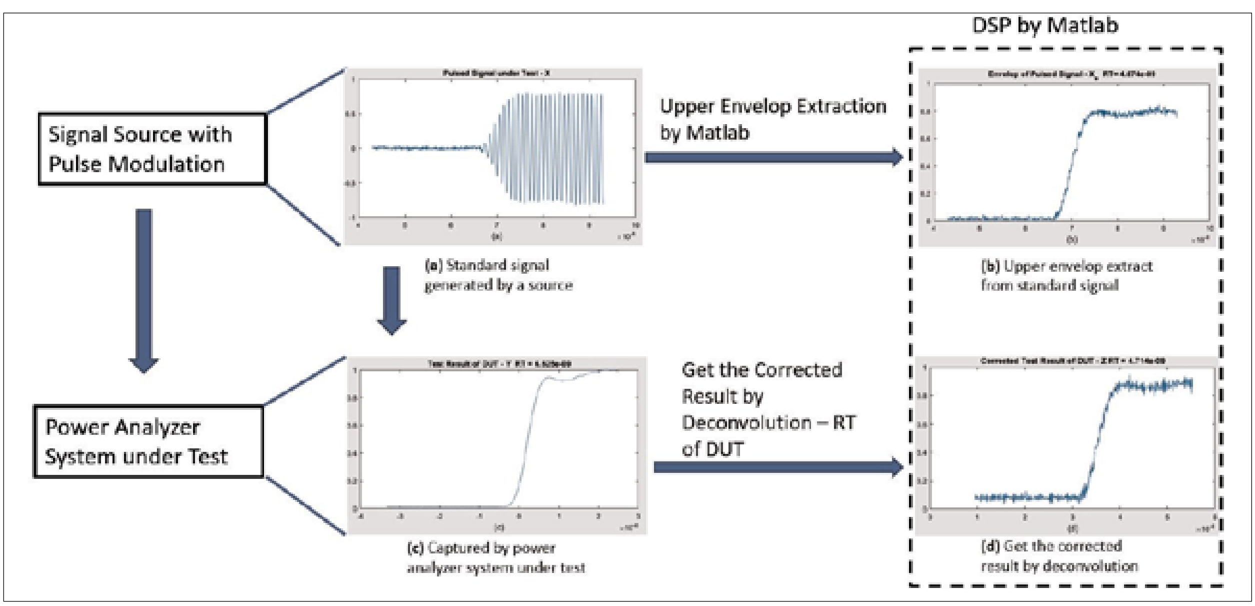

Figure 6. The deconvolution process for the power sensor time response test

- The corrected rise time of the power sensor system under test by deconvolution is 4.71 ns.
- The corrected rise time of the power sensor system under test by traditional RSS calculation: SQRT(6.62^2 – 4.67^2) = 4.70 ns.
- The difference between RSS and deconvolution is 4.70 – 4.71 = 0.01 ns.

Remarkably, the corrected rise time obtained through deconvolution closely aligns with the RSS method. This observation suggests that the case under consideration may exhibit Gaussian behavior, as discussed in the preceding section of the paper.

4.3 Noise Reduction for the Deconvolution Result

In the context of deconvolution, noise sensitivity presents a significant challenge. Deconvolution is highly sensitive to noise, and the envelope trace of a pulse-modulated signal acquires noise from both the measurement process and the envelope extraction. As a consequence, the deconvolution result frequently includes additional noise, adversely affecting its accuracy.

Several different techniques have been explored to mitigate noise in the resulting signal, considering both the time and frequency domains [8]. Among these approaches, wavelet denoising has gained prominence [9]. The efficacy of wavelet denoising stems from the wavelet transform's capacity to decompose a signal into distinct time-frequency components. By tuning the scaling parameter, we obtain a multi-resolution representation that is particularly effective for denoising tasks, especially in scenarios with rapid variations.

A crucial parameter is a positive integer referred to as the "wavelet level," which can be used to enhance noise suppression. Figure 7 visually demonstrates the influence of different wavelet denoising levels on rise time calculations. While denoising at level 4 exhibits minimal improvement, escalating to

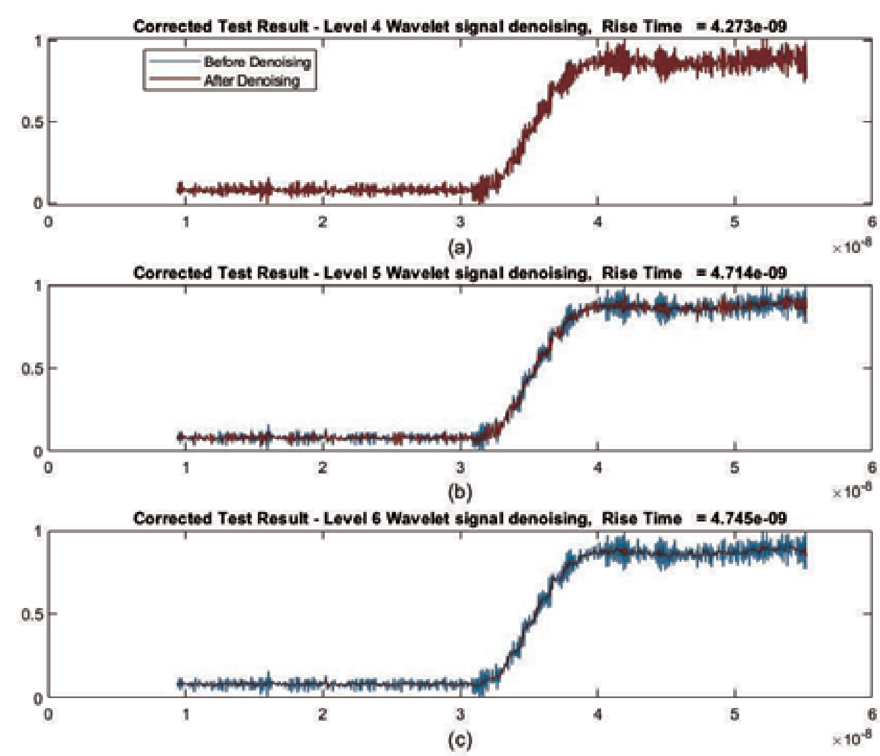

Figure 7. Wavelet denoising with different levels

levels 5 or 6 progressively eliminates noise from the rising edge. Remarkably, a consistent rise time of approximately 4.7 ns can be achieved even at higher wavelet levels (7, 8, or 9), thereby reinforcing the accuracy of the 4.7 ns result. The anomalous value of 4.3 ns obtained at wavelet level 4 underscores the impact of signal-to-noise ratio on precise rise time estimation.

The rise time results exhibit slight variations contingent upon the chosen wavelet denoising level. Specifically, for this particular case, the rise time values are as follows: 4.71 ns (at level 5), 4.74 ns (at level 6), 4.70 ns (at level 7), and 4.67 ns (at level 8). These subtle fluctuations can be attributed to the smoothness of the trace, which subtly influences the rise time estimation. The small change of approximately ±0.035 ns introduces an error in the deconvolution process and contributes to the overall uncertainty analysis.

5. Conclusion

The RSS calculation has gained widespread use due to its simplicity. However, its applicability across diverse cases remains limited. In contrast, the deconvolution method emerges as a robust alternative, particularly when uncertainty surrounds the effectiveness of the RSS approach. Notably, deconvolution is less sensitive to the precise shape of the time response.

We introduce a live test to demonstrate the comprehensive process of assessing the time response of a wideband power sensor. Initially, we extract an envelope trace from the RF-pulsed signal acquired via an oscilloscope. By judiciously selecting an appropriate filter length, we achieve a precise rise trace shape devoid of excessive ripple. Remarkably, the deconvolution process yields a rise time result akin to the RSS method when both the standard signal and the device under test exhibit "Gaussian" or "Gaussian-like" rise shapes. However, deconvolution grapples with a well-known adversary: noise. To address this challenge, wavelet denoising emerges as an effective solution, capitalizing on its advantageous, multi-resolution capability.

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Rohde & Schwarz Presents New R&S NGC100 Power Supply Series with Market-Leading Functions

The latest DC power supplies from Rohde & Schwarz for every-day manual use in the laboratory as well as for automated applications offer an extremely wide range of functions for entry level instruments. The R&S NGC100 power supply series includes one, two, and three-channel models supplying up to 32 V, 10 A and 100 W DC power.

Munich, Germany, 04 Apr 2024 – DC power supplies are essential throughout the electronics industry to provide the basic requirement of accurate and stable DC power from an AC source that may be subject to fluctuations and surges. The new R&S NGC100 power supply series not only meets this fundamental requirement, but also includes features, functions, and remote-control capabilities to support applications far more complex than steady output power. The series includes one, two, and three-channel models supplying 0-32 V per channel at up to 10 A and 100 W power output. The single-channel R&S NGC101 delivers up to 10 A, the two-channel R&S NGC102 up to 5 A per channel, and the three-channel R&S NGC103 up to 3 A per channel. Small and light, two R&S NGC100 can be mounted next to each other in a 19” rack to optimize test setup footprints.

Each channel in the two and three channel models is fully isolated for maximum flexibility. Users can use the channels independently as fully independent, extremely compact power supplies. Or they can combine the channels in series to increase the maximum potential difference to 96 V, or in parallel for currents up to 10 A. Full galvanic isolation means that channels can be connected to supply balanced circuits without worrying about grounding complications.

The basic performance of the R&S NGC100 as a power supply is excellent, both in terms of output range and output quality regarding low ripple and noise. The application support and additional features exceed expectations for this class of instrument. The remote sensing function ensures accuracy as users measure the voltage at the input of the circuit being powered, not at the output of the power supply. Users can also program voltage or current changes for a test sequence or avoid steep ramp-ups to protect the device being powered, or simulate operating conditions.

The R&S NGC100 puts safety first by providing a full range of protective functions for electrical and thermal properties. Users can set the time and define sequences for switching on channels. Voltage and current values for the circuit to be powered can be logged.

All models of the R&S NGC100 have a standard dual interface with USB and LAN ports, and an optional GPIB interface is available for remote control. For external control, a digital trigger supports input in Transistor-Transistor-Logic format to trigger functions such as logging. It is also possible to input sequences of voltage or current changes from an external program. An analog interface with a maximum input of 10V and 20 mA controls near-immediate changes in output voltage or current across the full range.

The R&S NGC100 power supply series replaces the R&S HMC804x power supplies, both as a drop-in replacement and to use together as required. The instruments are part of the R&S Essentials portfolio, available from Rohde & Schwarz and selected distribution channel partners.

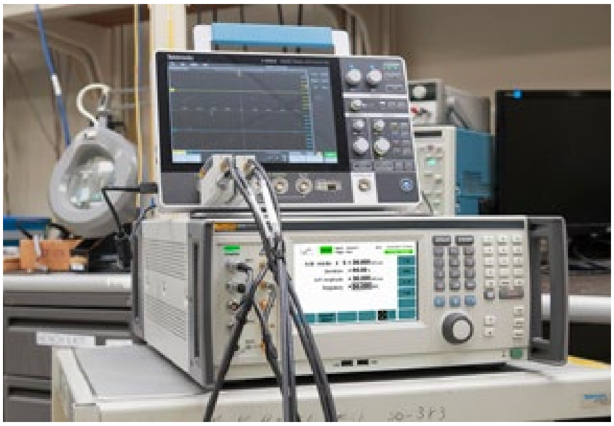
For more information on the R&S NGC100 power supply series visit: www.rohde-schwarz.com/product/NGC100

Fluke Calibration 9500C High-Performance Oscilloscope Calibrator Provides Key to Exceptional Signal Performance

The 9500C provides greater confidence that oscilloscopes are calibrated to maintain accurate and reliable data

EVERETT, Wash., April 2, 2024 — Calibration technicians need efficient, reliable oscilloscopes to reduce costly errors, delays, and safety issues. Given the complexity of these scopes – with thousands of test points – operators need an automated method to reduce testing time. The new Fluke 9500C High-Performance Oscilloscope Calibrator is designed to meet the demands of today’s technicians.

With a dedicated modern oscilloscope calibrator for professionals needing to cover workloads below 4 GHz accurately, reliably, and efficiently, the 9500C features include simultaneous outputs on all channels, which increase test speed and efficiency, and eliminate lead changes. The 9500C also boasts additional improvements over its predecessor with better accuracy, a more robust Active Head Technology™, updated hardware and software, and



a modern color touch screen interface. The 9500C can be fully automated with MET/CAL software for hands-free operation.

"Customers need confidence their oscilloscopes are calibrated to maintain accurate and reliable data – which can be a huge, time-consuming challenge given the complexity of these scopes," said Wally Miller product program manager, electrical/RF for Fluke Calibration. "We've designed the 9500C with the user in mind, automating time-consuming testing to deliver accurate, reliable data while reducing operator time."

The 9500C features technology innovations and performance improvements including:

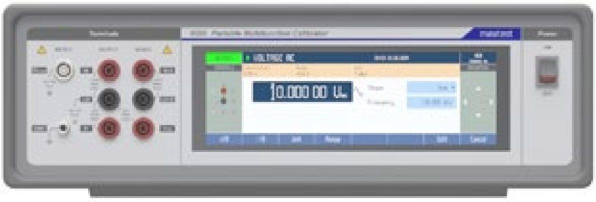
- A fully automated, multi-channel output for faster throughput and simultaneous measurements. The ability to actively drive all four heads at the same time with simultaneous output means faster test times and reduced operator interaction. Simply leave the scope plugged in and running for reduction in test and measurement time.
- A more accurate signal to test a wide range of oscilloscopes gives users greater confidence that they have what they need to get the job done.
- Plus, technicians can expand calibration abilities with Active Head Technology™ generating calibration signals right at the oscilloscope input.
- Easy-to-use updated user interface with the familiarity of the 9500B, and greater reliability.
- Removing many mechanical components from the heads, allowing for a removable and replaceable cable and connector.

For more information about Fluke Calibration, visit the Fluke Calibration website or visit the 9500C product page for details.

Meatest's 9000 Portable Multifunction Calibrator Sets New Standard in Calibration

Orlando, FL, May 2024 – Leading the way in precision calibration technology, Meatest proudly introduces the 9000 Portable Multifunction Calibrator. Engineered to redefine accuracy and convenience, the 9000 is a versatile tool meticulously designed for the calibration of 3½ and 4½ digit multimeters. This innovative device ensures unparalleled performance with an impressive array of features, all within a remarkably compact and lightweight form.

The 9000 calibrator is a true marvel of engineering, capable of handling a wide range of calibration tasks with exceptional precision. Weighing only 24 lbs/11 kg, the 9000 is as portable as a briefcase, making it the ideal solution for onsite calibrations. Despite its compact size, it boasts the capability to deliver up to 1050 V and 20.5 A, along with comprehensive resistance, capacitance, and temperature measurements.



Key Features:

- Voltage and Current Output Range: Up to 1050 V and 20.5 A, perfect for modern handheld workloads.
- Exceptional Functionality: Includes resistance, capacitance, thermocouples (TC), resistance temperature detectors (RTDs), and frequency.
- Exceptional Accuracy: Basic accuracy of 60 ppm ensures precise and reliable results.
- Advanced Touchscreen Interface: An 8" touchscreen display with large control zones simplifies operation and enhances user comfort.
- Build to Last: A 5 Year Warranty, based on its advanced design technology, underscores the maximum reliability provided to the instrument user.

Designed with the user in mind, the 9000's intuitive 8" touchscreen display allows for easy and error-free operation. The large control zones minimize accidental operator errors, while the well-thought-out touch control design ensures a smooth and efficient user experience.

The 9000 calibrator is equipped with USB, Ethernet, and IEEE488 interfaces, making it fully automation-ready. This allows for seamless integration into calibration labs and industrial test rigs. Additionally, the 9000 is compatible with the Meatest calibration software package CALIBER/WinQBase, including the CamOCR Camera Readout Module, which enhances the efficiency of handheld multimeter calibration.

Building on the legacy of its predecessor, the M143, the 9000 brings a broader frequency range and capacitance function, along with stronger outputs to handle the demands of modern calibration tasks. It's designed to cover a wide range of applications, including LoZ function calibration, panel meters, process meters, and more.

With the 9000 Portable Multifunction Calibrator, Meatest is setting a new standard in calibration technology. Its unmatched accuracy, versatility, and user-friendly design make it the ultimate tool for calibration professionals.

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AUTOMATION CORNER

Remote Debugging in the 21st Century

Michael L. Schwartz
Cal Lab Solutions, Inc.

Now that more jobs have a "work from home" aspect, I thought I would focus this Automation Corner on how debugging has changed over the years.

Back in the late 1990s, I first started working with customers debugging Fluke MET/CAL® procedures from my office in Oregon. The technology was pretty much new then and I think we, at Intercal, were the first company in the automation industry to remotely debug a procedure.

I started using the GoTo products. GoTo Support allowed customers to come to our website and download some software. Then, we could remotely see their screen and control the keyboard and mouse. Stepping through the procedure, we could find and resolve issues quickly—well, most of the time.

The problem back then was network speed. Few companies had a high-speed internet connection, and most people used 56k dial-up connections. I remember being the second person in town to get a cable modem installed—first on the list was the manager of the local cable company.

Back then, latency, the time it took to type something and see it appear on your screen, was murder; you really had to think ahead, type something and wait. If you made a mistake, you had to remember the backspace key also has a delay. So you would count, hit the backspace key 1,2,3,4,5 times, then type. And wait.

I was usually on the phone with the customer the whole time, asking questions about what they could see on the instruments. It worked, but often, it was so slow that I would only use GoTo Support to get an idea of what was wrong. Then, I would edit the procedure on my computer and send the customer an update.

Today, the internet is way faster! But the traffic has also increased, and the latency is still there! The problem is we are moving so much more data over the internet, coupled with some companies threatening specific ports and traffic.

We now have Facetime, WhatsApp, and several other instant chat and messaging tools, which have helped with remote debugging.

A few years ago, we started a meeting with a US-based metrology technician, who then took remote control of a workstation down in Brazil. But, the remote computer didn't have a microphone. So, there we are using Facetime to see what the hardware was doing as we are remote debugging the software.

This is how much technology has changed over the years!

Last week, I worked on a Keysight N9030B procedure running half a world away in Malaysia. I needed to see what the hardware was doing. I could see that for the I/O Trace, the commands were getting sent, but the readings were wrong, way wrong. The remote computer didn't have video, so the technician pulled out his phone and sent me a video via WhatsApp.

This saved me hours of troubleshooting, because I could see the UUT was not getting set up correctly. Now, I can go back and check the syntax in my VISAScript. Having written automation like this for years, I know that if the command syntax is correct, to check the order of execution. Sometimes, the unit required commands to be sent in a specific order.

We have so many tools that make remote support and debugging easier. I can't wait to see what comes next. Maybe VR headsets and robots that can press buttons and spin knobs?

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