



## CPEM Virtual Technical Program

### Conventional Electrical Standards

#### Session: Capacitance

#### Further research on the NIM's new vertical calculable cross-capacitor with latest optimal hollow active auxiliary electrode

Lu Huang<sup>1</sup>, Yan Yang<sup>1</sup>, Lu Zuliang<sup>1</sup>, Wei Wang<sup>1</sup>, Jianbo Wang<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China

#### Progress report on the LNE Thompson-Lampard Calculable Capacitor

Olivier Thevenot<sup>1</sup>, Almazbek Imanaliev<sup>1</sup>, Kamel Dougdag<sup>1</sup>, Francois Piquemal<sup>1</sup>

<sup>1</sup>Laboratoire national de métrologie et d'essais (LNE), Trappes, Yvelines, France

#### Improvements on Laser Interferometer in Calculable Capacitor at NIM

Jianbo Wang<sup>1</sup>, Cong Yin<sup>1</sup>, Jin Qian<sup>1</sup>, Chunying Shi<sup>1</sup>, Lu Huang<sup>1</sup>, Yan Yang<sup>1</sup>, mingyu zhang<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China

#### Experiments on Linking the von Klitzing Constant and the Farad at NIM

Yan Yang<sup>1</sup>, Lu Huang<sup>1</sup>, Yunfeng Lu<sup>1</sup>, Jianting Zhao<sup>1</sup>, Jianbo Wang<sup>1</sup>, Wei Wang<sup>1</sup>, Lu Zuliang<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China

#### Impedance Metrology: Bridging the LF-RF Gap

Marco Agustoni<sup>1</sup>, Frederic Overney<sup>1</sup>

<sup>1</sup>METAS, Bern-Wabern, Bern, Switzerland

#### Calibration of 10 nF Capacitance Standard from dc QHR using a Digital Impedance Bridge

Ngoc Thanh Mai Tran<sup>1</sup>, Wan-Seop Kim<sup>2</sup>, Dan Bee Kim<sup>2</sup>

<sup>1</sup>Politecnico di Torino, Torino, Piedmont, Italy, <sup>2</sup>Korea Research Institute of Standards and Science (KRISS), Daejeon, Daejeon, South Korea

#### Establishment of 4TP air capacitance standard for 1 pF, 10 pF, 100 pF and 1000 pF in the frequency range up to 30 MHz at NIMT

Monthol Homklintian, National Institute of Metrology (Thailand), Klong Luang, Pathum Thani, Thailand

## Determining inductive residual parameters for capacitance standards from S-parameter measurements

**Miha Kokalj**, Matjaž Lindič<sup>1</sup>, Klemen Stibernik<sup>2</sup>, Borut Pinter<sup>1</sup>, Marko Berginc<sup>1</sup>

<sup>1</sup>SIQ Ljubljana, Ljubljana, Slovenia, <sup>2</sup>SIQ Ljubljana, Zagorje ob Savi, Zasavje, Slovenia



## CPEM Virtual Technical Program

### Conventional Electrical Standards

#### Session: Current

#### Comparison between two dc low current traceability chains

Luca Callegaro<sup>1</sup>, Cristina Cassiogo<sup>1</sup>, Vincenzo D'Elia<sup>1</sup>, Emanuele Enrico<sup>1</sup>, Enrico Gasparotto<sup>1</sup>, Ilaria Finardi<sup>1</sup>, Martin Goetz<sup>2</sup>

<sup>1</sup>Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy, <sup>2</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany

#### Ohm's Law Low-current Calibration System for Ionization Chambers

Dean Jarrett<sup>1</sup>, Shamith Payagala<sup>1</sup>, Ryan Fitzgerald<sup>1</sup>, Denis Bergeron<sup>1</sup>, Jeffrey Cessna<sup>1</sup>, Charles J. Waduwarage Perera<sup>1</sup>, Neil Zimmerman<sup>1</sup>

<sup>1</sup>National Institute of Standards and Technology, Gaithersburg, MD

#### In-circuit current measurements with a frequency above 1 MHz: a shunt based on active components

Iliia Kolevatov<sup>1</sup>, Bjørnar Karlsen<sup>1</sup>, Kristian Ellingsberg<sup>1</sup>, Tore Sørdsdal<sup>1</sup>, Helge Malmbekk<sup>1</sup>

<sup>1</sup>Justervesenet, Kjeller, Norway

#### Comparison amplitude error of current shunts at frequencies up to 100 kHz between NMIA and NIM

Xianlin Pan<sup>1</sup>, Ilya Budovsky<sup>2</sup>, Vasukan Balakrishnan<sup>2</sup>, Zhaomin Shi<sup>1</sup>, Jiangtao Zhang<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China, <sup>2</sup>National Measurement Institute Australia, West Lindfield, NSW, Australia

#### Comparison of phase angle errors of current shunts between NMIA and NIM

Xianlin Pan<sup>1</sup>, Ilya Budovsky<sup>2</sup>, Vasukan Balakrishnan<sup>2</sup>, Zhaomin Shi<sup>1</sup>, Jiangtao Zhang<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China, <sup>2</sup>National Measurement Institute Australia, West Lindfield, NSW, Australia

#### Modeling Wideband Low-Current Shunts with a New Design

Gregory A. Kyriazis<sup>1</sup>, Regiane Souza<sup>1</sup>, Eliana Yasuda<sup>2</sup>, Lucas Di Lillo<sup>2</sup>

<sup>1</sup>Instituto Nacional de Metrologia, Qualidade e Tecnologia (Inmetro), Duque de Caxias, RJ, Brazil, <sup>2</sup>Instituto Nacional de Tecnología Industrial (INTI), San Martín, Buenos Aires, Argentina

## **A wideband current shunt**

**Marian Kampik**<sup>1</sup>, Maciej Malinowski<sup>1</sup>, Michal Grzenik<sup>1</sup>, Krzysztof Kubiczek<sup>1</sup>, Kordian Dudzik<sup>1</sup>

<sup>1</sup>*Silesian University of Technology, Gliwice, Poland*

## **Fabrication of High-Current Multijunction Thermal Current Converters on Silicon Substrates by Wet Chemical Etching**

**Yasutaka Amagai**<sup>1</sup>, Stefan Cular<sup>2</sup>, Joseph A. Hagmann<sup>2</sup>, Thomas Lipe<sup>3</sup>, Nobu-Hisa Kaneko<sup>1</sup>

<sup>1</sup>*National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan*, <sup>2</sup>*National Institute of Standards and Technology, Gaithersburg, MD*, <sup>3</sup>*Stanly Metrology Consultants, Richfield, NC*

## **Bilateral comparison of current transformer measuring systems of NCHVM and PTB**

**Xue Wang**<sup>1</sup>, Enrico Mohns<sup>2</sup>, Sören Rose<sup>2</sup>, Chun Yang Jiang<sup>1</sup>, Qiong Xiang<sup>1</sup>

<sup>1</sup>*National Center For High Voltage Measurement, Wuhan, Hubei, China*, <sup>2</sup>*Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany*

## **A Stable 24 A, 100 kHz Transconductance Amplifier**

Gregory A. Kyriazis, Instituto Nacional de Metrologia, Qualidade e Tecnologia (Inmetro), Duque de Caxias, RJ, Brazil



## CPEM Virtual Technical Program

### Conventional Electrical Standards

#### Session: DC Resistance

#### Extending the Calibration Capabilities of High Resistance

Bernhard H. Schumacher<sup>1</sup>, Christian Rohrig<sup>1</sup>

<sup>1</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany

#### Evaluation of an alternative null detector for adapted Wheatstone bridge

Shamith Payagala<sup>1</sup>, Alana Dee<sup>2</sup>, Dean Jarrett<sup>1</sup>

<sup>1</sup>National Institute of Standards and Technology, Gaithersburg, MD, <sup>2</sup>University of Pittsburgh, Swanson School of Engineering, Pittsburgh, PA

#### Evaluation of NMIJ Traveling Dual Source Bridge Using NIST Adapted Wheatstone Bridge

Takehiko Oe<sup>1</sup>, Shamith Payagala<sup>2</sup>, Dean Jarrett<sup>2</sup>, Nobu-Hisa Kaneko<sup>1</sup>

<sup>1</sup>National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan, <sup>2</sup>National Institute of Standards and Technology, Gaithersburg, MD

#### Pilot Study on Transport Behaviour of 100- $\Omega$ Standard Resistors for Use in APMP Key Comparisons

Kuan Hoong Lim<sup>1</sup>, Sze Wey Chua<sup>1</sup>, Takehiko Oe<sup>2</sup>, Nobu-Hisa Kaneko<sup>2</sup>

<sup>1</sup>National Metrology Centre, A\*STAR, Singapore, Singapore, <sup>2</sup>National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan

#### Method for the Calibration of Cryogenic Current Comparator Ratios

Yunfeng Lu<sup>1</sup>, Jianting Zhao<sup>1</sup>, Qing He<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China



## CPEM Virtual Technical Program

### Conventional Electrical Standards

#### Session: DC and AC Voltage

#### Noise and stability of Fluke 8588A in digitizing mode

Martin Šíra, Czech Metrology Institute, Brno, Czech Republic

#### Investigation of the Influence of Humidity on the Output Voltage of a Prototype of a Compact Detachable Zener Module

Michitaka Maruyama<sup>1</sup>, Chiharu Urano<sup>1</sup>, Nobu-Hisa Kaneko<sup>1</sup>, Takahiro Kanai<sup>2</sup>, Eiji Sannomaru<sup>2</sup>, Jun Honjo<sup>2</sup>, Isao Tanaka<sup>2</sup>, Yuji Yoshino<sup>2</sup>

<sup>1</sup>National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan, <sup>2</sup>ADC Corporation, Saitama, Japan

#### Research on the Technology of Calibrating millivolt AC voltage Source

Ding Xiang<sup>1</sup>, Huang Yan<sup>1</sup>, Zhang Lei<sup>1</sup>, Xianlin Pan<sup>2</sup>, Zhaomin Shi<sup>2</sup>, Jiangtao Zhang<sup>2</sup>

<sup>1</sup>Beijing Institute of Metrology, Beijing, Beijing, China, <sup>2</sup>National Institute of Metrology (NIM), Beijing, China

#### Keysight 3458A Digitiser Complex Frequency Response Identification using a Band Limited Square Wave

Rado Lapuh<sup>1</sup>, Luis Palafox<sup>2</sup>, Ralf Behr<sup>2</sup>, Boštjan Voljč<sup>3</sup>

<sup>1</sup>Metrology Institute of the Republic of Slovenia, Ljubljana, Slovenia, <sup>2</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany, <sup>3</sup>SIQ Ljubljana, Ljubljana, Slovenia

#### Linearity Measurements on Critical Noise Thermometer Components

Christian Krause<sup>1</sup>, Dietmar Drung<sup>1</sup>

<sup>1</sup>Physikalisch-Technische Bundesanstalt (PTB), Berlin, Berlin, Germany

#### Stable AC-DC Source for Josephson and Impedance Measurement Systems

Waldemar G. Kürten Ihlenfeld, National Research Council Canada, Ottawa, Ontario

#### The NRC Sampling System for Josephson Standards

Waldemar G. Kürten Ihlenfeld<sup>1</sup>, Ghislain Granger<sup>1</sup>

<sup>1</sup>National Research Council Canada, Ottawa, Ontario

## **An Externally-Linear-Internally-Nonlinear RMS-to-DC converter**

**Marian Kampik<sup>1</sup>**, Adam Pilsniak<sup>1</sup>

<sup>1</sup>*Silesian University of Technology, Gliwice, Poland*

## **Measurement of Arbitrary Waveforms at Low Frequencies**

**Tezgül Coşkun Öztürk<sup>1</sup>**, Ali Tangel, Sarp Ertürk, Mehedin Arifovic<sup>1</sup>

<sup>1</sup>*TÜBİTAK UME, Gebze, Kocaeli, Turkey*, <sup>2</sup>*University of Kocaeli*

## **Temperature influence on the establishment of a digital voltage reference**

**Javier Diaz de Aguilar<sup>1</sup>**, Yolanda A. Sanmamed<sup>1</sup>, Raul Caballero<sup>1</sup>, José Ramón Salinas<sup>2</sup>

<sup>1</sup>*Centro Español Metrología, Tres Cantos, Madrid, Spain*, <sup>2</sup>*Universidad de Málaga, Malaga, Malaga, Spain*



## CPEM Virtual Technical Program

### Conventional Electrical Standards

#### Session: Digital Bridges

#### Error sources in electronic fully-digital impedance bridges

Massimo Ortolano<sup>1</sup>, **Martina Marzano**<sup>2</sup>, Vincenzo D'Elia<sup>2</sup>, Ngoc Thanh Mai Tran<sup>1</sup>, Ryszard Rybski<sup>3</sup>, Janusz Kaczmarek<sup>3</sup>, Mirosław Kozioł<sup>3</sup>, Krzysztof Musioł<sup>4</sup>, Andreas E. Christensen<sup>5</sup>, Andrei Pokatillov<sup>6</sup>, Luca Callegaro<sup>2</sup>, Jan Kučera<sup>7</sup>, Oliver Power<sup>8</sup>

<sup>1</sup>Politecnico di Torino, Torino, Piedmont, Italy, <sup>2</sup>Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy, <sup>3</sup>University of Zielona Góra, Zielona Góra, Poland, <sup>4</sup>Silesian University of Technology, Gliwice, Poland, <sup>5</sup>Trescal A/S, Silkeborg, N/A, Denmark, <sup>6</sup>AS Metrosert, Tallinn, Estonia, <sup>7</sup>Czech Metrology Institute, Brno, Czech Republic, <sup>8</sup>National Standards Authority of Ireland, Dublin, Dublin, Ireland

#### Evaluations of a Sampling Impedance Bridge

**Yicheng Wang**<sup>1</sup>, Stephan Schlamming<sup>1</sup>, Bryan Waltrip<sup>1</sup>, Michael Berilla<sup>1</sup>

<sup>1</sup>National Institute of Standards and Technology, Gaithersburg, MD

#### Performance Study of a Digital Impedance Bridge on the basis of Capacitance Measurements in Audio Frequency

**Dan Bee Kim**<sup>1</sup>, Wan-Seop Kim<sup>1</sup>

<sup>1</sup>Korea Research Institute of Standards and Science (KRISS), Daejeon, Daejeon, South Korea

#### A Four Terminal Pair Digitally Assisted Impedance Bridge at TÜBİTAK UME

**Enis Turhan**<sup>1</sup>, Gülay Gülmez<sup>1</sup>, Ömer Erkan<sup>1</sup>, Cem Hayırlı<sup>1</sup>

<sup>1</sup>TÜBİTAK UME, Gebze, Kocaeli, Turkey





## CPEM Virtual Technical Program

### Conventional Electrical Standards

#### Session: Voltage Ratio and AC-DC Difference

#### On Determination of Complex Ratio of AC Voltages in a Simultaneously Sampled Two-Channel Data Acquisition System

Marian Kampik<sup>1</sup>, Jerzy Augustyn<sup>2</sup>, Krzysztof Musioł<sup>1</sup>

<sup>1</sup>Silesian University of Technology, Gliwice, Poland, <sup>2</sup>Kielce University of Technology, Kielce, -, Poland

#### A New Method for Precision Calibration of Resistive Voltage Dividers up to 1000 V

Ilya Budovsky, National Measurement Institute Australia, West Lindfield, NSW, Australia

#### A wideband 1 kV resistive divider with double shielding

Tobias Bergsten<sup>1</sup>, Karl-Erik Rydler<sup>1</sup>

<sup>1</sup>RISE Research Institutes of Sweden, Borås, Västra Götaland, Sweden

#### Incremental Buildup Calibration Method of Inductive Voltage Divider

Jian Feng<sup>1</sup>, Yang Pan<sup>1</sup>, Lei Lai<sup>1</sup>, Xianlin Pan<sup>2</sup>, Jiangtao Zhang<sup>2</sup>

<sup>1</sup>Shanghai Institute of Measurement and Testing Technology, Shanghai, Shanghai, China, <sup>2</sup>National Institute of Metrology (NIM), Beijing, China

#### Comparison of Voltage Divider In-phase and Quadrature Error Measurement Between NMIA and NIM

Xianlin Pan<sup>1</sup>, Ilya Budovsky<sup>2</sup>, Zhaomin Shi<sup>1</sup>, Jiangtao Zhang<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China, <sup>2</sup>National Measurement Institute Australia, West Lindfield, NSW, Australia

#### AC-DC Transfer System for Ultra-low Frequency Voltage

Zhaomin Shi<sup>1</sup>, Jiangtao Zhang<sup>1</sup>, Xianlin Pan<sup>1</sup>, Zhengsen Jia<sup>1</sup>, Ying Song<sup>1</sup>, Xuefeng Ma<sup>2</sup>, Qing He<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China, <sup>2</sup>Shandong Province Institute of Metrology, Jinan City, Shandong Province, China

#### AC-DC Difference Measurement of 792A at Millivolt Voltage

Zhaomin Shi<sup>1</sup>, Xianlin Pan<sup>1</sup>, Qianjuan Wang<sup>2</sup>, Zhengsen Jia<sup>1</sup>, Ying Song<sup>1</sup>, Jiangtao Zhang<sup>1</sup>, Qing He<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China, <sup>2</sup>Beijing Oriental Institute of Metrology & Test, Beijing, Beijing, China

## **Analysis of Frequency-Dependent Component of AC – DC Transfer Difference of a Modified Calorimetric Thermal Converter**

**Marian Kampik**<sup>1</sup>, Krzysztof Kubiczek<sup>1</sup>, Michal Grzenik<sup>1</sup>

<sup>1</sup>*Silesian University of Technology, Gliwice, Poland*

## **A new AC-DC transfer device for high voltages and high frequencies using electrooptic modulation**

**Torsten Funck**<sup>1</sup>, André Müller<sup>1</sup>, Thomas Spiegel<sup>1</sup>

<sup>1</sup>*Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany*

## **Digital Sampling of Quantum Accurate AC and DC waveforms**

**Ghislain Granger**<sup>1</sup>, Waldemar G. Kürten Ihlenfeld<sup>1</sup>

<sup>1</sup>*National Research Council Canada, Ottawa, Ontario*

## **A TVM Based Wideband Phase Measurement System by Multiusing One Thermal Voltage Converter**

**Tatsuji Yamada**<sup>1</sup>, Yasutaka Amagai<sup>1</sup>

<sup>1</sup>*National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan*

## **Reducing Multijunction Thermal Converter Output Resistance to Reduce Measurement Noise**

**Joseph A. Hagmann**<sup>1</sup>, Charles J. Waduwarage Perera<sup>1</sup>, Stefan Cular<sup>1</sup>

<sup>1</sup>*National Institute of Standards and Technology, Gaithersburg, MD*

## **New Generation Multijunction Thermal Converters at Sandia National Laboratories**

**Raegan Johnson**<sup>1</sup>, Aaron Meyrick<sup>1</sup>, Jason Dominguez<sup>1</sup>, Karl Lukes<sup>1</sup>, Joshua Stanford<sup>1</sup>, Stefan Cular<sup>2</sup>, Edward D. O'Brien<sup>1</sup>

<sup>1</sup>*Sandia National Laboratories, Albuquerque, NM*, <sup>2</sup>*National Institute of Standards and Technology, Gaithersburg, MD*

## **Hybrid Buffer Amplifier for AC-DC Difference Measurement Applications**

**Shannon Edwards**<sup>1</sup>, Charles J. Waduwarage Perera<sup>1</sup>, Stefan Cular<sup>1</sup>

<sup>1</sup>*National Institute of Standards and Technology, Gaithersburg, MD*



## CPEM Virtual Technical Program

### Conventional Electrical Standards

#### Session: Other Impedance

#### Results of GULFMET Supplementary Comparison for Inductance of 10 mH and 100 mH at Frequency 1 kHz

Oleh Velychko<sup>1</sup>, Sergii Shevkun<sup>1</sup>, Jon Bartholomew<sup>2</sup>, Abdullah Alrobaish<sup>3</sup>, Tetyana Gordiyenko<sup>4</sup>  
<sup>1</sup>State Enterprise "Ukrmetrteststandard", Kyiv, Kyiv, Ukraine, <sup>2</sup>Abu Dhabi Quality and Conformity Council Emirates Metrology Institute, Abu Dhabi, Abu Dhabi, United Arab Emirates, <sup>3</sup>Saudi Standards Metrology and Quality Organization (NMCC-SASO), Riyadh, Saudi Arabia, <sup>4</sup>Odesa State Academy of Technical Regulation and Quality, Odesa, Odesa, Ukraine

#### Synthetic inductance standards made up of capacitances and gyrators

Torsten Funck<sup>1</sup>, André Müller<sup>1</sup>, Harald Bothe<sup>1</sup>  
<sup>1</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany

#### A Two-Stage Buffer Amplifier with Local Positive Feedback

Jianting Zhao<sup>1</sup>, Yunfeng Lu<sup>1</sup>, Qing He<sup>1</sup>, Yicheng Wang<sup>2</sup>  
<sup>1</sup>National Institute of Metrology (NIM), Beijing, China, <sup>2</sup>National Institute of Standards and Technology, Gaithersburg, MD

#### Quasi-balanced method of measuring the dielectric loss factor

Marian Kampik<sup>1</sup>, Adam Cichy<sup>1</sup>  
<sup>1</sup>Silesian University of Technology, Gliwice, Poland

#### Frequency Dependence Determination of Resistors at the BIPM

Jose Angel Moreno Hernandez<sup>1</sup>, Pierre Gournay<sup>1</sup>, Benjamin Rolland<sup>1</sup>, Norihiko Sakamoto<sup>2</sup>  
<sup>1</sup>BIPM, Sèvres, Hauts-de-Seine, France, <sup>2</sup>National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan

#### Compensated high input impedance stage for the measurements of four terminals resistors up to 20 kHz

Agazar Agazar<sup>1</sup>, Oumauer Mohamed<sup>1</sup>  
<sup>1</sup>Laboratoire national de métrologie et d'essais (LNE), Trappes, Yvelines, France



## CPEM Virtual Technical Program

### High Voltage and Current

#### Session: Ratio and Sensors

#### Calibrating Sensors to Measure Braking Chopper Currents in DC Traction Units

Helko E. van den Brom<sup>1</sup>, Ronald van Leeuwen<sup>1</sup>

<sup>1</sup>VSL B.V., Delft, Netherlands

#### A Study of Voltage Dependence of a High DC Voltage Divider

Brian A. Miranda Quisbert<sup>1</sup>, Jose L. Casais<sup>1</sup>, Marcos E. Bierzychudek<sup>1</sup>, Harold Parks<sup>2</sup>, Branislav Djokic<sup>2</sup>

<sup>1</sup>Instituto Nacional de Tecnología Industrial (INTI), San Martín, Buenos Aires, Argentina, <sup>2</sup>National Research Council Canada, Ottawa, Ontario

#### Research and verification of DC current ratio self-calibration method

Liren Zhou<sup>1</sup>, Yang Pan<sup>1</sup>, Lei Lai<sup>1</sup>

<sup>1</sup>Shanghai Institute of Measurement and Testing Technology, Shanghai, Shanghai, China

#### Measuring the Voltage Dependence of Current Transformers

Ronald van Leeuwen<sup>1</sup>, Helko E. van den Brom<sup>1</sup>, Gert Rietveld<sup>1</sup>, Ernest Houtzager<sup>1</sup>, Dennis Hoogenboom<sup>1</sup>

<sup>1</sup>VSL B.V., Delft, Netherlands

#### SIM Comparison of AC Current Ratio Using Instrument Current Transformers

Daniel Slomovitz<sup>1</sup>, Alejandro Santos<sup>1</sup>, Rogelio Sandler<sup>1</sup>, Gabriela Barreto<sup>1</sup>, Gonzalo Aristoy<sup>1</sup>, Jose L. Casais<sup>2</sup>, Patrícia Cals de Oliveira Vitorio<sup>3</sup>, Alvaro Zipaquirá Triana<sup>4</sup>, Julio Gonzalez<sup>5</sup>, Sergio Ochoa<sup>6</sup>, Enrico Mohns<sup>7</sup>

<sup>1</sup>UTE, Montevideo, Uruguay, <sup>2</sup>Instituto Nacional de Tecnología Industrial (INTI), San Martín, Buenos Aires, Argentina, <sup>3</sup>Instituto Nacional de Metrologia, Qualidade e Tecnologia (Inmetro), Duque de Caxias, RJ, Brazil, <sup>4</sup>Instituto Nacional de Metrología, Bogotá D.C., Bogotá D.C., Colombia, <sup>5</sup>CENAMEP, Panama, Panama, Panama, <sup>6</sup>LAPEM, Irapuato, Irapuato, Mexico, <sup>7</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany

## High Precision 500 / $\sqrt{3}$ kV Two-Stage Voltage Transformer with High-Voltage Excitation

Hao Liu<sup>1</sup>, Min Lei<sup>1</sup>, Feng Zhou<sup>1</sup>, Xiaodong Yin<sup>1</sup>, Lixue Chen<sup>2</sup>, Chun Yang Jiang<sup>3</sup>, Jian Liu<sup>3</sup>

<sup>1</sup>China Electric Power Research Institute (CEPRI), Wuhan, Hubei, China, <sup>2</sup>Huazhong University of Science and Technology, wuhan, hubei, China, <sup>3</sup>National Center For High Voltage Measurement, Wuhan, Hubei, China

## Development of a Wideband Current-to-Voltage Transformer Set for Currents up to 2 kA

Yeying Chen<sup>1</sup>, Enrico Mohns<sup>1</sup>, Henrik Badura<sup>1</sup>, Peter Raether<sup>1</sup>

<sup>1</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany

## Self-Calibrating High Precision Current Transformer

Daniel Slomovitz<sup>1</sup>, Alejandro Santos<sup>1</sup>, Rogelio Sandler<sup>1</sup>, Gabriela Barreto<sup>1</sup>

<sup>1</sup>UTE, Montevideo, Uruguay

## Traceable Characterization of Low Power Voltage Instrument Transformers for PQ and PMU Applications

Gabriella Crotti<sup>1</sup>, Domenico Giordano<sup>1</sup>, Palma Sara Letizia<sup>1</sup>, Antonio Delle Femine<sup>2</sup>, Danielle Gallo<sup>3</sup>, Carmine Landi<sup>2</sup>, Mario Luiso<sup>4</sup>

<sup>1</sup>Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy, <sup>2</sup>University of Campania "Luigi Vanvitelli", Aversa, Caserta, Italy, <sup>3</sup>University of Campania "Luigi Vanvitelli", Caserta, N.A., Italy, <sup>4</sup>Università degli studi della Campania, Aversa, CE, Italy

## Calibration of Weld Current Monitors at INTI Argentina

Jose L. Casais<sup>1</sup>, Marcos E. Bierzychudek<sup>1</sup>, Branislav Djokic<sup>2</sup>, Harold Parks<sup>2</sup>

<sup>1</sup>Instituto Nacional de Tecnología Industrial (INTI), San Martin, Buenos Aires, Argentina, <sup>2</sup>National Research Council Canada, Ottawa, Ontario

## Development and Applications of Wideband High Current Transducers

Haiming Shao<sup>1</sup>, Chuansheng Li<sup>1</sup>, Feipeng Lin<sup>1</sup>, Lixin Wang<sup>1</sup>, Bo Liang<sup>1</sup>, Jiafu Wang<sup>1</sup>, Wei Zhao<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China

## Development of Voltage-Doubling Method for Measuring the Voltage Dependence of Compressed Gas Capacitors up to 400 kV

Yang Pan<sup>1</sup>, Liren Zhou<sup>1</sup>, Jian Feng<sup>1</sup>, Lei Lai<sup>1</sup>, Guo z. Zhan<sup>1</sup>, Haiming Shao<sup>2</sup>

<sup>1</sup>Shanghai Institute of Measurement and Testing Technology, Shanghai, Shanghai, China, <sup>2</sup>National Institute of Metrology (NIM), Beijing, China

## Accurate Error-Voltage Determination for Calibrating 1000V Inductive Voltage Dividers

Enrico Mohns<sup>1</sup>, Henrik Badura<sup>1</sup>, Sören Rose<sup>1</sup>

<sup>1</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany

## **Verification of High Voltage Divider with $10 \cdot 10^{-6}$ Uncertainty**

Gu Ye<sup>1</sup>, Wei Zhao<sup>2</sup>, **Gert Rietveld**<sup>1</sup>

<sup>1</sup>VSL B.V., Delft, Netherlands, <sup>2</sup>National Institute of Metrology (NIM), Beijing, China

## **Metrological analysis of voltage transducers under multi-harmonic signals**

**Leonardo A. Souza**<sup>1</sup>, Renata T. Vasconcellos<sup>1</sup>, Marcelo B. Martins<sup>1</sup>, Antonio C. Lima<sup>1</sup>

<sup>1</sup>Instituto Nacional de Metrologia, Qualidade e Tecnologia (Inmetro), Duque de Caxias, RJ, Brazil

## **Development of Wide-band Current Transformer for Precision Measurement of High-Current**

**Lin Feipeng**<sup>1</sup>, Bo Liang<sup>1</sup>, Haiming Shao<sup>1</sup>, Hao Wang<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China





## CPEM Virtual Technical Program

### High Voltage and Current

#### Session: Other High Voltage and Current

#### Characterization of Cable Effects on a Reference Lightning Impulse Voltage Divider

Jussi Havunen<sup>1</sup>, Stephan Passon<sup>2</sup>, Jari Hällström<sup>3</sup>, Johann Meisner<sup>2</sup>, Tim Schlüterbusch<sup>2</sup>

<sup>1</sup>VTT MIKES, Espoo, Uusimaa, Finland, <sup>2</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany, <sup>3</sup>VTT MIKES, Espoo, Finland

#### Mechanical Structure for fast Voltage Coefficients Determination of Compressed-gas Capacitor with Tilting Technic

Huanghui Zhang<sup>1</sup>, Haiming Shao<sup>2</sup>, Jiafu Wang<sup>2</sup>, Wei Zhao<sup>2</sup>, Chuansheng Li<sup>2</sup>

<sup>1</sup>Fujian Institute of Metrology, Fuzhou, Fujian, China, <sup>2</sup>National Institute of Metrology (NIM), Beijing, China

#### Software Corrections for Switching Impulse Voltage Divider Response

Jussi Havunen<sup>1</sup>, Jari Hällström<sup>2</sup>

<sup>1</sup>VTT MIKES, Espoo, Uusimaa, Finland, <sup>2</sup>VTT MIKES, Espoo, Finland

#### One Factor for Oscillation on the Front of Impulse Voltage Waveforms

Wei Zhao<sup>1</sup>, Haiming Shao<sup>1</sup>, Chuansheng Li<sup>1</sup>, Jiafu Wang<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China

#### Challenges Associated with Implementation of HFCTs for Partial Discharge Measurements

Joni Kluss<sup>1</sup>, Alf-Peter Elg<sup>1</sup>

<sup>1</sup>RISE Research Institutes of Sweden, Borås, Västra Götaland, Sweden

#### Development of a standard measuring system for High-Voltage Nanosecond Pulse Measurements

Mohammad S. Khan<sup>1</sup>, Agazar Agazar<sup>1</sup>, Yann Le Bihan<sup>2</sup>

<sup>1</sup>Laboratoire national de métrologie et d'essais (LNE), Trappes, Yvelines, France, <sup>2</sup>Université Paris-Saclay, CentraleSupélec, CNRS, Sorbonne Université Laboratoire de Génie Electrique et Electronique de Paris, Gif-sur-Yvette, Ile de France, France

## **Calibration Device of High Voltage Capacitance Bridge**

**Dongxue Dai**<sup>1</sup>, Wei Wang<sup>1</sup>, Yan Yang<sup>1</sup>, Yan Chen<sup>1</sup>

<sup>1</sup>*National Institute of Metrology (NIM), Beijing, China*

## **Correction on the Impulse Scale Factor and Time Parameters of the Reference Divider Based on the Step Response and Convolution**

Yang Pan, Shanghai Institute of Measurement and Testing Technology, Shanghai, Shanghai, China





## CPEM Virtual Technical Program

### Novel Sensors and Measurements

#### Session: Novel Sensors and Measurements I

#### Portable Electrostatic Force Balance for Laser Power Metrology

Gordon Shaw<sup>1</sup>, Frank C. Seifert<sup>1</sup>, Jon Pratt<sup>1</sup>, David Newell<sup>1</sup>, Stephan Schlamming<sup>1</sup>

<sup>1</sup>National Institute of Standards and Technology, Gaithersburg, MD

#### Tests of a novel 3 DOF differential capacitive sensor

Andrea Sosso<sup>1</sup>, Gian Bartolo Picotto<sup>1</sup>, Roberto Bellotti<sup>1</sup>

<sup>1</sup>Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy

#### Magnetic sensing with Nitrogen-vacancy center based on lock-in detection

Andrea Sosso<sup>1</sup>, Ekaterina Moreva<sup>1</sup>, Ettore Bernardi<sup>1</sup>, Paolo Traina<sup>1</sup>, Giulia Petrini<sup>1</sup>, Sviatoslav Ditalia<sup>2</sup>, Jacopo Forneris<sup>2</sup>, Federico Picollo<sup>2</sup>, Vanna Pugliese<sup>3</sup>, Z. Pastuovic<sup>4</sup>, Ivo Degiovanni<sup>1</sup>, Paolo Olivero<sup>2</sup>, Marco Genovese<sup>1</sup>

<sup>1</sup>Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy, <sup>2</sup>INFN, Torino, n/a, Italy, <sup>3</sup>University of Torino, Torino, n/a, Italy, <sup>4</sup>Australian Nuclear Science and Technology Organisation, Lucas Heights, n/a, Australia

#### Thermoelectricity in Corbino devices in the quantum Hall regime

Alejandra Tonina<sup>1</sup>, Mariano Real<sup>1</sup>, Liliana Arrachea<sup>1</sup>, Daniel Gresta, Werner Dietsche

<sup>1</sup>Instituto Nacional de Tecnología Industrial (INTI), San Martín, Buenos Aires, Argentina, <sup>2</sup>ICAS-UNSAM, Argentina, <sup>3</sup>ETH, Switzerland

#### Fabrication and properties of Nb/Al-AlO<sub>x</sub>/Nb Josephson junctions for SQUID application

Da Xu<sup>1</sup>, Jinjin Li<sup>1</sup>, Wenhui Cao<sup>1</sup>, Jianshe Liu<sup>2</sup>, Wei Chen<sup>2</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China, <sup>2</sup>Tsinghua University, Beijing, Beijing, China

#### On-chip Josephson junction-based sensor for temperature control of a cryocooled quantum standard

Paolo Durandetto<sup>1</sup>, Andrea Sosso<sup>2</sup>

<sup>1</sup>Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy, Italy, <sup>2</sup>Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy



## CPEM Virtual Technical Program

### Novel Sensors and Measurements

#### Session: Novel Sensors and Measurements II

#### Defect Detection and Identification of Point-Focusing Shear-Horizontal EMAT for Plate Inspection

Lisha Peng<sup>1</sup>, Hongyu Sun<sup>1</sup>, Shen Wang<sup>1</sup>, Qing Wang<sup>2</sup>, Wei Zhao<sup>1</sup>, Songling Huang<sup>1</sup>

<sup>1</sup>Tsinghua University, Beijing, Beijing, China, <sup>2</sup>Durham University, Durham, Durham, United Kingdom

#### Effect of Focal Position for Oblique Point Focusing Shear Horizontal Guided Wave EMAT

Hongyu Sun<sup>1</sup>, Lisha Peng<sup>1</sup>, Songling Huang<sup>1</sup>, Shen Wang<sup>1</sup>, Qing Wang<sup>2</sup>, Wei Zhao<sup>1</sup>

<sup>1</sup>Tsinghua University, Beijing, Beijing, China, <sup>2</sup>Durham University, Durham, Durham, United Kingdom

#### Effective Focal Area Dimension Optimization of Shear-Horizontal Point-Focusing EMAT Using Orthogonal Test Method

Hongyu Sun<sup>1</sup>, Lisha Peng<sup>1</sup>, Shen Wang<sup>1</sup>, Qing Wang<sup>2</sup>, Wei Zhao<sup>1</sup>, Songling Huang<sup>1</sup>

<sup>1</sup>Tsinghua University, Beijing, Beijing, China, <sup>2</sup>Durham University, Durham, Durham, United Kingdom

#### Sparse Reconstruction Based Time-frequency Representation for Time-of-flight Extraction of Undersampled Lamb Wave Signal

Zhe Wang<sup>1</sup>, Songling Huang<sup>1</sup>, Shen Wang<sup>1</sup>, Qing Wang<sup>2</sup>, Wei Zhao<sup>1</sup>

<sup>1</sup>Tsinghua University, Beijing, Beijing, China, <sup>2</sup>Durham University, Durham, Durham, United Kingdom

#### Sensitive Calorimeter based on Coupled Dielectric Resonators

Ling Hao<sup>1</sup>, Tom Quincey<sup>1</sup>, Giuseppe Lorusso<sup>1</sup>, John Keightley<sup>1</sup>, Jie Chen<sup>2</sup>, John Gallop<sup>1</sup>

<sup>1</sup>National Physical Laboratory, Teddington, Middlesex, United Kingdom, <sup>2</sup>Department of Mechanical and Aerospace Engineering, Brunel University, Uxbridge, London, United Kingdom

#### Measuring relaxation rate of atomic vapor cell by Microwave field detection technique

Ning Ru<sup>1</sup>, Xiaochi Liu<sup>1</sup>, Junyi Duan<sup>1</sup>, Jifeng Qu<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China

## **A phase measurement method to guarantee the traceability of the calibration systems**

Segio Rapuano<sup>1</sup>, Pasquale Daponte<sup>1</sup>, Luca De Vito<sup>1</sup>, Francesco Picariello<sup>1</sup>, **Ioan Tudosa**<sup>1</sup>, Nicholas G. Paulter<sup>2</sup>

<sup>1</sup>*University of Sannio, Benevento, BN, Italy*, <sup>2</sup>*National Institute of Standards and Technology, Gaithersburg, MD*

## **Coulomb Blockade Thermometry on a Wide Temperature Range**

Ossi Hahtela<sup>1</sup>, Antti Kemppinen<sup>2</sup>, Janne Lehtinen<sup>2</sup>, **Antti Manninen**<sup>2</sup>, Emma Mykkänen<sup>2</sup>, Mika Prunnila<sup>2</sup>, Nikolai Yurttagül<sup>2</sup>, Florian Blanchet<sup>3</sup>, Matthias Gramich<sup>4</sup>, Bayan Karimi<sup>3</sup>, Elsa Mannila<sup>3</sup>, Jesse Muhojoki<sup>3</sup>, Joonas Peltonen<sup>3</sup>, Jukka Pekola<sup>3</sup>

<sup>1</sup>*Vaisala Oyj, Vantaa, -, Finland*, <sup>2</sup>*VTT MIKES, Espoo, Finland*, <sup>3</sup>*Aalto University, Espoo, -, Finland*, <sup>4</sup>*Munich University of Applied Sciences, Munich, -, Germany*



## CPEM Virtual Technical Program

### Power and Energy

#### Session: Harmonics and Analysis

#### Trilateral South American Project: A Reference System for Measuring Electric Power up to 100 kHz – Current Status

**Gregory A. Kyriazis**<sup>1</sup>, Lucas Di Lillo<sup>2</sup>, Daniel Slomovitz<sup>3</sup>, Ricardo Iuzzolino<sup>2</sup>, Eliana Yasuda<sup>2</sup>, Leonardo Trigo<sup>3</sup>, Regiane Souza<sup>1</sup>, Hector Laiz<sup>2</sup>, Edson Afonso<sup>1</sup>

<sup>1</sup>Instituto Nacional de Metrologia, Qualidade e Tecnologia (Inmetro), Duque de Caxias, RJ, Brazil, <sup>2</sup>Instituto Nacional de Tecnología Industrial (INTI), San Martín, Buenos Aires, Argentina, <sup>3</sup>UTE, Montevideo, Uruguay

#### Harmonic Voltage Measurement based on Program Josephson Voltage Standard

**Zhengsen Jia**<sup>1</sup>, Xitong Xu<sup>1</sup>, Lei Wang<sup>1</sup>, Jiangtao Zhang<sup>1</sup>, Xianlin Pan<sup>1</sup>, Zhaomin Shi<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China

#### Research on Harmonic Voltage Measurement Accuracy Based on AC Quantum Voltage

Xitong Xu<sup>1</sup>, **Zhengsen Jia**<sup>1</sup>, Lei Wang<sup>1</sup>, Tiandi Zhou<sup>1</sup>, Jiangtao Zhang<sup>1</sup>, Xianlin Pan<sup>1</sup>, Zhaomin Shi<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China

#### Calibration of Electrical Instruments under Non-sinusoidal Conditions at NRC Canada

**Branislav Djokic**<sup>1</sup>, Harold Parks<sup>1</sup>

<sup>1</sup>National Research Council Canada, Ottawa, Ontario

#### Testing Electric Utility Smart Meters with High Harmonic Current Waveforms

**Richard Steiner**<sup>1</sup>, Tom Nelson<sup>1</sup>, Shannon Edwards<sup>1</sup>, Julia Codere<sup>2</sup>

<sup>1</sup>National Institute of Standards and Technology, Gaithersburg, MD, <sup>2</sup>University of Maryland, College Park, MD

#### An Instantaneous Power Quantities Measurement Method Based on Wavelet Packet Transform

**Yiqing Yu**<sup>1</sup>, Wei Zhao<sup>1</sup>, Songling Huang<sup>1</sup>

<sup>1</sup>Tsinghua University, Beijing, Beijing, China

## Comparison of AC Power Referenced to Either PJVS or JAWS

**Bryan Waltrip**<sup>1</sup>, Tom Nelson<sup>1</sup>, Michael Berilla<sup>1</sup>, Nathan E. Flowers-Jacobs<sup>2</sup>, Paul Dresselhaus<sup>2</sup>

<sup>1</sup>*National Institute of Standards and Technology, Gaithersburg, MD*, <sup>2</sup>*National Institute of Standards and Technology, Boulder, CO*



## CPEM Virtual Technical Program

### Power and Energy

#### Session: Smart Grid and Phase

#### Frequency-Domain Sampling Theorem-based Harmonic Phasor Estimator

Lei Chen<sup>1</sup>, Wei Zhao<sup>1</sup>, **Dongfang Zhao<sup>1</sup>**, Songling Huang<sup>1</sup>

<sup>1</sup>*Tsinghua University, Beijing, Beijing, China*

#### Extended Calibration Setup for IEC 61850-9-2 Devices

**Marco Agustoni<sup>1</sup>**, Alessandro Mortara<sup>1</sup>

<sup>1</sup>*METAS, Bern-Wabern, Bern, Switzerland*

#### Online Verification System for Phasor Measurement Units

**Leonardo Trigo<sup>1</sup>**, Daniel Slomovitz<sup>1</sup>, Daniel Izquierdo<sup>1</sup>, Agustin Garcia<sup>1</sup>, Carlos Faverio<sup>1</sup>, Luis Astesiano<sup>1</sup>

<sup>1</sup>*UTE, Montevideo, Uruguay*

#### Reference system for PMU calibration

**Lucas Di Lillo<sup>1</sup>**, Luciano D. Domínguez Pose<sup>1</sup>

<sup>1</sup>*Instituto Nacional de Tecnología Industrial (INTI), San Martin, Buenos Aires, Argentina*

#### Input Low-Pass Filter Characterization of Agilent 3458 Digitizers

Luciano D. Domínguez Pose, Instituto Nacional de Tecnología Industrial (INTI), San Martin, Buenos Aires, Argentina

#### Software Automation for Bandwidth Testing of Keysight 3458A Digital Multimeter up to 200 kHz

**Yang Pan<sup>1</sup>**, Feng Xu<sup>1</sup>, Jian Feng<sup>1</sup>, Liren Zhou<sup>1</sup>, Lei Lai<sup>1</sup>, Ming h. Zhang<sup>1</sup>, Hong t. Huang<sup>1</sup>

<sup>1</sup>*Shanghai Institute of Measurement and Testing Technology, Shanghai, Shanghai, China*

#### A Digital Heterodyne 2-150 kHz Measurement Method

Paul Wright<sup>1</sup>, **Deborah Ritzmann<sup>1</sup>**

<sup>1</sup>*National Physical Laboratory, Teddington, Middlesex, United Kingdom*

#### Specification of New Test Waveforms for Static Electricity Meters

**Deborah Ritzmann<sup>1</sup>**, Paul Wright<sup>1</sup>

<sup>1</sup>*National Physical Laboratory, Teddington, Middlesex, United Kingdom*

## Measurement of 2-150 kHz Conducted Emissions in Power Networks

**Deborah Ritzmann**<sup>1</sup>, Paul Wright<sup>1</sup>, Jan Meyer<sup>2</sup>, Victor Khokhlov<sup>2</sup>, David De la Vega<sup>3</sup>, Igor Fernandez<sup>3</sup>  
<sup>1</sup>National Physical Laboratory, Teddington, Middlesex, United Kingdom, <sup>2</sup>Technical University Dresden, Dresden, Sachsen, Germany, <sup>3</sup>University of the Basque Country, Bilbao, Basque Country, Spain

## An Isolator to eliminate grounding issues for wideband power measurements

**Peter Davis**<sup>1</sup>, Paul Wright<sup>1</sup>

<sup>1</sup>National Physical Laboratory, Teddington, Middlesex, United Kingdom

## Uncertainty of ROCOF calculated by means of Monte Carlo method

Martin Šíra, Czech Metrology Institute, Brno, Czech Republic

## Measurement Methods and Procedures for Assessing Accuracy of Instrument Transformers for Power Quality Measurements

**Gabriella Crotti**<sup>1</sup>, Helko E. van den Brom<sup>2</sup>, Enrico Mohns<sup>3</sup>, Roberto Tinarelli<sup>4</sup>, Mario Luiso<sup>5</sup>, Renata Styblikova<sup>6</sup>, Agazar Agazar<sup>7</sup>, Huseyin Cayci<sup>8</sup>, Jan Meyer<sup>9</sup>, Paolo Mazza<sup>10</sup>, Mohammed Almutairi<sup>11</sup>

<sup>1</sup>Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy, <sup>2</sup>VSL B.V., Delft, Netherlands, <sup>3</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany, <sup>4</sup>Alma Mater Studiorum - Università di Bologna, Bologna, Italy, <sup>5</sup>Università degli studi della Campania, Aversa, CE, Italy, <sup>6</sup>Czech Metrology Institute, Brno, Czech Republic, <sup>7</sup>Laboratoire national de métrologie et d'essais (LNE), Trappes, Yvelines, France, <sup>8</sup>TÜBİTAK UME, Gebze, Kocaeli, Turkey, <sup>9</sup>Technical University Dresden, Dresden, Sachsen, Germany, <sup>10</sup>Ricerca sul Sistema Energetico S.p.A (RSE), Milano, Italy, <sup>11</sup>Saudi Standards Metrology and Quality Organization (NMCC-SASO), Riyadh, Saudi Arabia

## The Detection of Power Quality Disturbances Based on Generalized S-transform

Chengbin Liang<sup>1</sup>, Zhaosheng Teng<sup>1</sup>, Jianmin Li<sup>1</sup>, Fangxing Liu<sup>2</sup>, **Qing He**<sup>3</sup>

<sup>1</sup>Hunan University, Changsha, Hunan, China, <sup>2</sup>Harbin Institute of Technology, Harbin, Heilongjiang Province, China, <sup>3</sup>National Institute of Metrology (NIM), Beijing, China

## Modelling of a Voltage Divider by Rational Functions for Power Quality

**Leonardo A. Souza**<sup>1</sup>, Marcelo B. Martins<sup>1</sup>, Antonio C. Lima<sup>1</sup>, Marcus V. Pinto<sup>1</sup>

<sup>1</sup>Instituto Nacional de Metrologia, Qualidade e Tecnologia (Inmetro), Duque de Caxias, RJ, Brazil





## CPEM Virtual Technical Program

### Power and Energy

#### Session: Other Power and Energy

#### **New AC Power Measurement Standard Based on Digital Sampling at CMS**

Kun-Long Chen<sup>1</sup>, Shih-Fang Chen<sup>1</sup>, Tsung-Han Ho<sup>1</sup>

<sup>1</sup>Center for Measurement Standards (CMS)/Industrial Technology Research Institute (ITRI), Hsinchu, Taiwan

#### **Main Results of GULFMET Supplementary Comparison for AC Active and Reactive Energy**

Oleh Velychko<sup>1</sup>, Huseyin Cayci<sup>2</sup>, Jon Bartholomew<sup>3</sup>, Stanislav Karpenko<sup>1</sup>

<sup>1</sup>State Enterprise "Ukrmetrteststandard", Kyiv, Kyiv, Ukraine, <sup>2</sup>TÜBİTAK UME, Gebze, Kocaeli, Turkey, <sup>3</sup>Abu Dhabi Quality and Conformity Council Emirates Metrology Institute, Abu Dhabi, Abu Dhabi, United Arab Emirates

#### **A measurement system for the characterization of wireless charging stations for electric vehicles**

Mauro Zucca<sup>1</sup>, Paolo Squillari<sup>2</sup>, Umberto Pogliano<sup>1</sup>

<sup>1</sup>Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy, <sup>2</sup>Custom 2.0 srl, Turin, Piedmont, Italy

#### **Calibration of Precision Current Transformers and AC Resistors by Comparison using Two Sampling Digital Voltmeters**

Ilya Budovsky, National Measurement Institute Australia, West Lindfield, NSW, Australia

#### **Accurate Measurement of Energy Dissipated in Braking Rheostats in DC Railway Systems**

Helko E. van den Brom<sup>1</sup>, Domenico Giordano<sup>2</sup>, Danielle Gallo<sup>3</sup>, Andreas Wank<sup>4</sup>, Yljon Seferi<sup>5</sup>

<sup>1</sup>VSL B.V., Delft, Netherlands, <sup>2</sup>Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy, <sup>3</sup>University of Campania "Luigi Vanvitelli", Caserta, N.A., Italy, <sup>4</sup>National Physical Laboratory, Glasgow, N.A., United Kingdom, <sup>5</sup>University of Strathclyde, GLASGOW, Scotland, United Kingdom

#### **Towards improved standardization of electricity meter testing**

Helko E. van den Brom<sup>1</sup>, Gert Rietveld<sup>1</sup>, Dennis Hoogenboom<sup>1</sup>, Ronald van Leeuwen<sup>1</sup>, Zander Marais<sup>1</sup>, Gertjan Kok<sup>1</sup>, Samridh Sharma<sup>1</sup>, Marijn van Veghel<sup>1</sup>

<sup>1</sup>VSL B.V., Delft, Netherlands



## Sensitivities and uncertainties of eco-driving algorithm estimating train power consumption

**Martin Šíra**<sup>1</sup>, Asunción P. Cucala<sup>2</sup>, Antonio Fernández-Cardador<sup>2</sup>, Adrián Fernández-Rodríguez<sup>2</sup>

<sup>1</sup>Czech Metrology Institute, Brno, Czech Republic, <sup>2</sup>Institute for Research in Technology, ICAI School of Engineering, Comillas Pontifical University, Madrid, -, Spain

## Calibration System for DC Power/Energy Measurement chain in Railway applications

Gabriella Crotti<sup>1</sup>, Antonio Delle Femine<sup>2</sup>, Danielle Gallo<sup>3</sup>, **Domenico Giordano**<sup>1</sup>, Mario Luiso<sup>4</sup>, Carmine Landi<sup>2</sup>, Davide Signorino<sup>1</sup>

<sup>1</sup>Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy, <sup>2</sup>University of Campania "Luigi Vanvitelli", Aversa, Caserta, Italy, <sup>3</sup>University of Campania "Luigi Vanvitelli", Caserta, N.A., Italy, <sup>4</sup>Università degli studi della Campania, Aversa, CE, Italy

## Electrical measurements at inductive charging stations for electric vehicles. An outcome from Micev project

**Mauro Zucca**<sup>1</sup>, Jorge Bruna Romero<sup>2</sup>, Vincenzo Cirimele<sup>3</sup>, Davide Signorino<sup>1</sup>, Erika Laporta Puyal<sup>2</sup>, Jacopo Colussi<sup>3</sup>, Miguel Angel Alonso Tejedor<sup>2</sup>, Federico Fissore<sup>1</sup>

<sup>1</sup>Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy, <sup>2</sup>CIRCE Foundation - Centro de Investigación de Recursos y Consumos Energéticos, Zaragoza, Zaragoza, Spain, <sup>3</sup>Politecnico di Torino, Torino, Piedmont, Italy

## Metrology-grade Precision ADC for Power and Energy Applications

**Ernest Houtzager**<sup>1</sup>, Zander Marais<sup>1</sup>, Gert Rietveld<sup>1</sup>, Tapio A. Lehtonen<sup>2</sup>

<sup>1</sup>VSL B.V., Delft, Netherlands, <sup>2</sup>VTT MIKES, Espoo, Finland

## The influence of LED lighting on the correctness of indications of electronic energy meters

**Marian Kampik**<sup>1</sup>, Artur Skorkowski<sup>1</sup>

<sup>1</sup>Silesian University of Technology, Gliwice, Poland

## An Approach for Online Smart Meter Error Estimation

**Fangxing Liu**<sup>1</sup>, Chengbin Liang<sup>2</sup>, Qing He<sup>3</sup>

<sup>1</sup>Harbin Institute of Technology, Harbin, Heilongjiang Province, China, <sup>2</sup>Hunan University, Changsha, Hunan, China, <sup>3</sup>National Institute of Metrology (NIM), Beijing, China

## An Accurate AC Current-to-Voltage Converter Based On a Fully Compensated Current Comparator

**Enrico Mohns**<sup>1</sup>, Alexander Dubowik<sup>1</sup>, Martin Goetz<sup>1</sup>

<sup>1</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany



## CPEM Virtual Technical Program

### Quantum Electrical Standards

#### Session: Josephson Impedance Bridge

#### Dual Josephson Impedance Bridge: Universal bridge for impedance metrology

**Frederic Overney**<sup>1</sup>, Blaise Jeanneret<sup>1</sup>, Nathan E. Flowers-Jacobs<sup>2</sup>, Alain Rüfenacht<sup>2</sup>, Anna Fox<sup>2</sup>, Paul Dresselhaus<sup>2</sup>, Samuel Benz<sup>2</sup>

<sup>1</sup>METAS, Bern-Wabern, Bern, Switzerland, <sup>2</sup>National Institute of Standards and Technology, Boulder, CO

#### AC Quantum Hall Resistance combined with a Four-Terminal Pair Pulse-Driven Josephson Impedance Bridge

**Stephan Bauer**<sup>1</sup>, Yaowaret Pimsut<sup>1</sup>, Ralf Behr<sup>1</sup>, Oliver Kieler<sup>1</sup>, Mattias Kruskopf<sup>1</sup>, Luis Palafox<sup>1</sup>, Jinni Lee<sup>1</sup>, Schurr Jürgen<sup>1</sup>

<sup>1</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany

#### A four-terminal-pair pulse-driven Josephson impedance bridge for 10 nF:10 nF capacitance ratio measurements

**Yaowaret Pimsut**<sup>1</sup>, Stephan Bauer<sup>1</sup>, Jonas Herick<sup>1</sup>, Luis Palafox<sup>1</sup>, Oliver Kieler<sup>1</sup>, Ralf Behr<sup>1</sup>

<sup>1</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany



## CPEM Virtual Technical Program

### Quantum Electrical Standards

#### Session: Josephson Voltage I: Josephson Arbitrary Waveform Synthesizer

##### Calibration of an AC Voltage Source Using a Josephson Arbitrary Waveform Synthesizer at 4 V

**Nathan E. Flowers-Jacobs<sup>1</sup>**, Alain Rüfenacht<sup>1</sup>, Anna Fox<sup>1</sup>, Paul Dresselhaus<sup>1</sup>, Samuel Benz<sup>1</sup>  
<sup>1</sup>National Institute of Standards and Technology, Boulder, CO

##### Zero-Compensation Josephson Arbitrary Waveform Synthesizer at 1.33 V

**Nathan E. Flowers-Jacobs<sup>1</sup>**, Akim Babenko<sup>1</sup>, Anna Fox<sup>1</sup>, Justus Brevik<sup>1</sup>, Paul Dresselhaus<sup>1</sup>, Samuel Benz<sup>1</sup>  
<sup>1</sup>National Institute of Standards and Technology, Boulder, CO

##### Evaluation of the Zero-Compensation Method Based on the Comparison of Two Pulse-Driven Josephson Voltage Standards

**Marco Kraus<sup>1</sup>**, Ralf Behr<sup>1</sup>, Oliver Kieler<sup>1</sup>, Stephan Bauer<sup>1</sup>, Luis Palafox<sup>1</sup>, Jonas Herick<sup>1</sup>  
<sup>1</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany

##### Load Compensation Bridge for Pulse-Driven Josephson Junction Arrays

**Blaise Jeanneret<sup>1</sup>**, Frederic Overney<sup>1</sup>, Stephan Bauer<sup>2</sup>, Ralf Behr<sup>2</sup>, Oliver Kieler<sup>2</sup>, Yaowaret Pimsut<sup>2</sup>  
<sup>1</sup>METAS, Bern-Wabern, Bern, Switzerland, <sup>2</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany

##### A fast negative impedance converter for JAWS load compensation

**Jason M. Underwood<sup>1</sup>**, Stephen Pfeiffer<sup>2</sup>, Geoffrey Palo<sup>2</sup>  
<sup>1</sup>National Institute of Standards and Technology, Gaithersburg, MD, <sup>2</sup>Joint Quantum Institute, College Park, MD

##### Applications of the Josephson based spectrum analyzer

**Luis Palafox<sup>1</sup>**, Jonas Herick<sup>1</sup>, Stephan Bauer<sup>1</sup>, Marco Kraus<sup>1</sup>, Oliver Kieler<sup>1</sup>, Ralf Behr<sup>1</sup>  
<sup>1</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany

## Josephson Arbitrary Waveform Synthesizer as a Reference Standard for the Calibration of Lock-in Amplifiers

**Dimitrios Georgakopoulos<sup>1</sup>**, Ilya Budovsky<sup>1</sup>, Samuel Benz<sup>2</sup>

<sup>1</sup>National Measurement Institute Australia, West Lindfield, NSW, Australia, <sup>2</sup>National Institute of Standards and Technology, Boulder, CO

## Realization of a Phase Reference System Based on Two Synchronized Pulse-Driven Josephson Voltage Standards

**Stephan Bauer<sup>1</sup>**, Matthias Schmidt<sup>1</sup>, Florian Beug<sup>1</sup>, Jonas Herick<sup>1</sup>, Oliver Kieler<sup>1</sup>, Ralf Behr<sup>1</sup>

<sup>1</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany

## Real-time quantum-accurate voltage waveform synthesis

**Jane Ireland<sup>1</sup>**, Stephen Protheroe<sup>1</sup>, Jonathan Williams<sup>1</sup>, Allan Belcher<sup>2</sup>, Ronald Dekker<sup>3</sup>, Kars Schaapman<sup>4</sup>, Ricardo Iuzzolino<sup>5</sup>, Rodrigo Melo<sup>5</sup>, Bruno Valinoti<sup>5</sup>, Marcos E. Bierzychudek<sup>5</sup>, Martin Šíra<sup>6</sup>, Jonas Herick<sup>7</sup>, Oliver Kieler<sup>7</sup>, Ralf Behr<sup>7</sup>

<sup>1</sup>National Physical Laboratory, Teddington, Middlesex, United Kingdom, <sup>2</sup>Signal Conversion, Killay, Swansea, United Kingdom, <sup>3</sup>Applicos, Zwolle, Zwolle, Netherlands, <sup>4</sup>Applicos, Zwolle, Zwolle, New Zealand, <sup>5</sup>Instituto Nacional de Tecnología Industrial (INTI), San Martin, Buenos Aires, Argentina, <sup>6</sup>Czech Metrology Institute, Brno, Czech Republic, <sup>7</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany

## Pulse-driven AC Josephson voltage standard at VNIIM

**Gleb Gubler<sup>1</sup>**, Alexander Katkov<sup>1</sup>, Vladimir Shevtsov<sup>1</sup>, Ralf Behr<sup>2</sup>, Anastasia Petrovskaya<sup>1</sup>, Oliver Kieler<sup>2</sup>

<sup>1</sup>VNIIM, Saint-Petersburg, Russia, <sup>2</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany

## Testing the Sampling System Using Josephson Arbitrary Waveform Synthesizer Established in TÜBİTAK UME

**Tezgül Coşkun Öztürk<sup>1</sup>**, Oliver Kieler<sup>2</sup>, Mehedin Arifovic<sup>1</sup>, Ralf Behr<sup>2</sup>

<sup>1</sup>TÜBİTAK UME, Gebze, Kocaeli, Turkey, <sup>2</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany



## CPEM Virtual Technical Program

### Quantum Electrical Standards

#### Session: Josephson Voltage II: Programmable Josephson Voltage Standard

##### Compact DC Josephson Voltage Standard

**Alain Rüfenacht<sup>1</sup>**, Anna Fox<sup>1</sup>, Grace Butler<sup>1</sup>, Burroughs Charles<sup>1</sup>, Paul Dresselhaus<sup>1</sup>, Schwall Robert<sup>1</sup>, Stefan Cular<sup>2</sup>, Samuel Benz<sup>1</sup>

<sup>1</sup>National Institute of Standards and Technology, Boulder, CO, <sup>2</sup>National Institute of Standards and Technology, Gaithersburg, MD

##### Automated Leakage Current Measurement Capability for Programmable Josephson Voltage Standards

**Burroughs Charles<sup>1</sup>**, Alain Rüfenacht<sup>1</sup>, Stefan Cular<sup>2</sup>, Paul Dresselhaus<sup>1</sup>

<sup>1</sup>National Institute of Standards and Technology, Boulder, CO, <sup>2</sup>National Institute of Standards and Technology, Gaithersburg, MD

##### Direct DC Voltages Comparison between two Programmable Josephson Voltage Standards at SCL

**Steven Yang<sup>1</sup>**, Stefan Cular<sup>2</sup>, Alain Rüfenacht<sup>3</sup>, Burroughs Charles<sup>3</sup>, Paul Dresselhaus<sup>3</sup>, Samuel Benz<sup>3</sup>, Chris Ng<sup>1</sup>

<sup>1</sup>Standards and Calibration Laboratory, Hong Kong, Hong Kong, <sup>2</sup>National Institute of Standards and Technology, Gaithersburg, MD, <sup>3</sup>National Institute of Standards and Technology, Boulder, CO

##### Cryocooled 10 V Programmable Josephson Voltage Standard at CMS

**Shih-Fang Chen<sup>1</sup>**, Chou-Hsun Han<sup>1</sup>, Stefan Cular<sup>2</sup>

<sup>1</sup>Center for Measurement Standards (CMS)/Industrial Technology Research Institute (ITRI), Hsinchu, Taiwan, <sup>2</sup>National Institute of Standards and Technology, Gaithersburg, MD

##### Implementation of Fluke 8588A multimeter for differential sampling of AC waveforms based on a programmable Josephson voltage standard

**Mun-Seog Kim<sup>1</sup>**, Hehee Cho<sup>1</sup>, Stéphane P. Solve<sup>2</sup>

<sup>1</sup>Korea Research Institute of Standards and Science (KRISS), Daejeon, Daejeon, South Korea, <sup>2</sup>BIPM, Sèvres, Hauts-de-Seine, France

## Software-assisted phase locking technique for Programmable Josephson Voltage Standard

**Patrick G. Reuvekamp**<sup>1</sup>, Helge Malmbekk<sup>2</sup>, Jane Ireland<sup>1</sup>, Eric Breakenridge<sup>3</sup>, Jonathan Williams<sup>1</sup>

<sup>1</sup>National Physical Laboratory, Teddington, Middlesex, United Kingdom, <sup>2</sup>Justervesenet, Kjeller, Norway, <sup>3</sup>Keysight Technologies, Edinburgh, West Lothian, United Kingdom

## Update on the future BIPM on-site comparison program for Josephson ac voltage standards

**Stéphane P. Solve**<sup>1</sup>, Mun-Seog Kim<sup>2</sup>, Luis Palafox<sup>3</sup>, Ralf Behr<sup>3</sup>, Ilya Budovsky<sup>4</sup>, Gleb Gubler<sup>5</sup>

<sup>1</sup>BIPM, Sèvres, Hauts-de-Seine, France, <sup>2</sup>Korea Research Institute of Standards and Science (KRISS), Daejeon, Daejeon, South Korea, <sup>3</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany, <sup>4</sup>National Measurement Institute Australia, West Lindfield, NSW, Australia, <sup>5</sup>VNIIM, Saint-Petersburg, Russia

## An AC quantum voltmeter for frequencies up to 100 kHz

**Ralf Behr**<sup>1</sup>, Luis Palafox<sup>1</sup>

<sup>1</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany

## Calibration of a precision current measurement system for high AC voltages using an AC Quantum Voltmeter

**Damir Ilić**<sup>1</sup>, Chantal Lüddecke<sup>2</sup>, Alexander Heinrich<sup>2</sup>, Johann Meisner<sup>2</sup>, Ralf Behr<sup>2</sup>

<sup>1</sup>Primary Electromagnetic Laboratory (FER-PEL), Zagreb, Zagreb, Croatia, <sup>2</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany

## Inductive Voltage Divider Ratio Measurement Based on Dual-Channel PJVS

**Zhengsen Jia**<sup>1</sup>, Tiandi Zhou<sup>1</sup>, Lei Wang<sup>1</sup>, Zhaomin Shi<sup>1</sup>, Xianlin Pan<sup>1</sup>, Jiangtao Zhang<sup>1</sup>, Xitong Xu<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China





## CPEM Virtual Technical Program

### Quantum Electrical Standards

#### Session: Josephson Voltage III: Miscellaneous

#### Superposition Johnson Noise Thermometry with a Quantum Voltage Noise Source for Calibration

Kunli Zhou<sup>1</sup>, Qina Han<sup>1</sup>, Yang Shi<sup>1</sup>, Miaoer Wang<sup>1</sup>, Jianting Zhao<sup>1</sup>, Jifeng Qu<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China

#### A Voltage-tracking scheme for Quantum-Metrology-Triangle Experiments

Daiki Matsumaru<sup>1</sup>, Zhengsen Jia<sup>2</sup>, Michitaka Maruyama<sup>1</sup>, Nobu-Hisa Kaneko<sup>1</sup>

<sup>1</sup>National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan, <sup>2</sup>National Institute of Metrology (NIM), Beijing, China

#### Realization of an Opto-Electronic Bias for Pulse-Driven Josephson Voltage Standards at PTB

Jonas Herick<sup>1</sup>, Luis Palafox<sup>1</sup>, Eivind Bardalen<sup>2</sup>, Stephan Bauer<sup>1</sup>, Ralf Behr<sup>1</sup>, Bjørnar Karlsen<sup>3</sup>, Oliver Kieler<sup>1</sup>, Helge Malmbekk<sup>3</sup>

<sup>1</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany, <sup>2</sup>University of South-Eastern Norway, Borre, Vestfold og Telemark, Norway, <sup>3</sup>Justervesenet, Kjeller, Norway

#### High-Speed Pulsation of a Cryogenically Operable Bipolar Photodiode Module for the Josephson Arbitrary Waveform Synthesizer

Bjørnar Karlsen<sup>1</sup>, Eivind Bardalen<sup>2</sup>, Jaani Nissilä<sup>3</sup>, Thomas Fordell<sup>3</sup>, Oliver Kieler<sup>4</sup>, Luis Palafox<sup>4</sup>, Ralf Behr<sup>4</sup>, Helge Malmbekk<sup>1</sup>, Muhammad Nadeem Akram<sup>2</sup>, Per Ohlckers<sup>2</sup>

<sup>1</sup>Justervesenet, Kjeller, Norway, <sup>2</sup>University of South-Eastern Norway, Borre, Vestfold og Telemark, Norway, <sup>3</sup>VTT MIKES, Espoo, Finland, <sup>4</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany

#### Development of an optical bias receiver for pulsed Josephson arrays cryocooler operation

Andrea Sosso<sup>1</sup>, Franco Delpiano<sup>1</sup>, Danilo Serazio<sup>1</sup>, Paolo Durandetto<sup>2</sup>, Oliver Kieler<sup>3</sup>

<sup>1</sup>Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy, <sup>2</sup>Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy, <sup>3</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany

## **Compact 18-channel bias source for 10 V programmable Josephson voltage standard arrays**

**Michael Starkloff<sup>1</sup>**, Hannes Preissler<sup>2</sup>, Marco Schubert<sup>1</sup>

<sup>1</sup>Supracon AG, Jena, Thuringia, Germany, <sup>2</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany

## **Development of Programmable Multichannel Precision Current Source**

**Wenhui Cao<sup>1</sup>**, Wenjuan Hou<sup>2</sup>, Wenjuan Hou<sup>2</sup>, Jinjin Li<sup>1</sup>, Honghui Li<sup>1</sup>, Zengmin Wang<sup>1</sup>, Yuan Zhong<sup>1</sup>, Qing Zhong<sup>1</sup>, Xueshen Wang<sup>1</sup>, Qing He<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China, <sup>2</sup>Boxin Communications Co., Ltd, Shijiazhuang, Hebei, China

## **A Programmable Current-controlled Voltage Source for Simulation of Josephson Junction Arrays**

**Yaqiong Fu<sup>1</sup>**, Jianting Zhao<sup>2</sup>, Lushuai Qian<sup>3</sup>, Jifeng Qu<sup>2</sup>

<sup>1</sup>China Jiliang University, Hangzhou, Zhejiang, China, <sup>2</sup>National Institute of Metrology (NIM), Beijing, China, <sup>3</sup>Tsinghua University, Beijing, Beijing, China

## **Research on Cryocooled Programmable Josephson Voltage Standard at NIM**

**Zengmin Wang<sup>1</sup>**, Honghui Li<sup>1</sup>, Fujian Liao<sup>1</sup>, Qing He<sup>1</sup>, Jifeng Qu<sup>1</sup>, Zhengkun Li<sup>1</sup>, Yuan Gao<sup>2</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China, <sup>2</sup>Beijing, Beijing, China

## **A Practical Microvolt Josephson Voltage Standard for Nanovoltmeter Measurement Based on Dual-Channel Josephson Junction Array**

**Honghui Li<sup>1</sup>**, Zengmin Wang<sup>1</sup>, Wenhui Cao<sup>1</sup>, Jinjin Li<sup>1</sup>, Qing He<sup>1</sup>, Zhengkun Li<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China

## **Series arrays of NbSi barrier junctions with rf power dividers for AC Josephson voltage standards**

**Johannes Kohlmann<sup>1</sup>**, Hao Tian<sup>1</sup>, Oliver Kieler<sup>1</sup>, Rolf Gerdau<sup>1</sup>, Bert Egeling<sup>1</sup>, Ralf Behr<sup>1</sup>

<sup>1</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany





## CPEM Virtual Technical Program

### Quantum Electrical Standards

#### Session: Quantum Current

#### Comparison of the Programmable Quantum Current Generator and an Ultrastable Low-Noise Current Amplifier

Sophie Djordjevic<sup>1</sup>, Wilfrid Poirier<sup>1</sup>, Dietmar Drung<sup>2</sup>, Martin Goetz<sup>3</sup>

<sup>1</sup>Laboratoire national de métrologie et d'essais (LNE), Trappes, Yvelines, France, <sup>2</sup>Physikalisch-Technische Bundesanstalt (PTB), Berlin, Berlin, Germany, <sup>3</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany

#### Directly Comparing the Current from Two Electron Pumps

Stephen P. Giblin<sup>1</sup>, Gento Yamahata<sup>1</sup>, Akira Fujiwara<sup>1</sup>, Patrick See<sup>1</sup>, Geb Jones<sup>1</sup>, Dave Ritchie<sup>1</sup>, Masaya Kataoka<sup>1</sup>, Ian Farrer<sup>1</sup>, Jonathan Griffiths<sup>1</sup>

<sup>1</sup>National Physical Laboratory, Teddington, Middlesex, United Kingdom

#### Calibration of sensitive ammeters using a noiseless electron pump

Stephen P. Giblin<sup>1</sup>, Gento Yamahata<sup>1</sup>, Akira Fujiwara<sup>1</sup>, Masaya Kataoka<sup>1</sup>

<sup>1</sup>National Physical Laboratory, Teddington, Middlesex, United Kingdom

#### GaAs/AlGaAs-based single-electron pumps developed in KRISS

Bum-Kyu Kim<sup>1</sup>, Wan-Seop Kim<sup>1</sup>, Myung-Ho Bae<sup>1</sup>, Sung Un Cho<sup>1</sup>

<sup>1</sup>Korea Research Institute of Standards and Science (KRISS), Daejeon, Daejeon, South Korea

#### Current-reversal technique for single-parameter electron pumps

Myung-Ho Bae<sup>1</sup>, Bum-Kyu Kim<sup>1</sup>, Byeong-Sung Yu<sup>1</sup>, Wan-Seop Kim<sup>1</sup>, Nam Kim<sup>1</sup>

<sup>1</sup>Korea Research Institute of Standards and Science (KRISS), Daejeon, Daejeon, South Korea

#### Study on Cold-Finger 3He Cryostat for Precision Measurements of Quantum Hall Resistance and Single-Electron Pump Current

Nam Kim<sup>1</sup>, Wan-Seop Kim<sup>1</sup>, Dong-Hun Chae<sup>1</sup>, Bum-Kyu Kim<sup>1</sup>, Young-Seok Ghee<sup>2</sup>, Myung-Ho Bae<sup>1</sup>

<sup>1</sup>Korea Research Institute of Standards and Science (KRISS), Daejeon, Daejeon, South Korea, <sup>2</sup>Korea Research Institute of Standards and Science (KRISS), Daejeon, Daejeon



## CPEM Virtual Technical Program

### Quantum Electrical Standards

#### Session: Quantum Resistance and Impedance

#### Current-to-Voltage Conversion with Integrated Quantum Hall Resistors

Dong-Hun Chae<sup>1</sup>, Mun-Seog Kim<sup>1</sup>, Wan-Seop Kim<sup>1</sup>, Takehiko Oe<sup>2</sup>, Nobu-Hisa Kaneko<sup>2</sup>

<sup>1</sup>Korea Research Institute of Standards and Science (KRISS), Daejeon, Daejeon, South Korea, <sup>2</sup>National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan

#### Sub-ppb type A uncertainty for QHR-measurements in a pulse tube cooled cryostat

Karin Cedergren<sup>1</sup>, Tobias Bergsten<sup>1</sup>, Gunnar Eklund<sup>1</sup>

<sup>1</sup>RISE Research Institutes of Sweden, Borås, Västra Götaland, Sweden

#### Metrological Suitability of Functionalized Epitaxial Graphene

Albert Rigosi<sup>1</sup>, Mattias Kruskopf<sup>1</sup>, Alireza R. Panna<sup>1</sup>, Shamith Payagala<sup>1</sup>, Dean Jarrett<sup>1</sup>, David Newell<sup>1</sup>, Rand Elmquist<sup>1</sup>

<sup>1</sup>National Institute of Standards and Technology, Gaithersburg, MD

#### Superconducting Contact Geometries for Next-Generation Quantized Hall Resistance Standards

Alireza R. Panna<sup>1</sup>, Mattias Kruskopf<sup>1</sup>, Albert Rigosi<sup>1</sup>, Martina Marzano<sup>2</sup>, Shamith Payagala<sup>1</sup>, Dean Jarrett<sup>1</sup>, David Newell<sup>1</sup>, Rand Elmquist<sup>1</sup>

<sup>1</sup>National Institute of Standards and Technology, Gaithersburg, MD, <sup>2</sup>Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy

#### AC and DC Quantized Hall Array Resistance Standards

Rand Elmquist<sup>1</sup>, Mattias Kruskopf<sup>2</sup>, Dinesh Patel<sup>3</sup>, I-Fan Hu<sup>1</sup>, Chieh-I Liu<sup>1</sup>, Albert Rigosi<sup>1</sup>, Alireza R. Panna<sup>1</sup>, Shamith Payagala<sup>1</sup>, Dean Jarrett<sup>1</sup>

<sup>1</sup>National Institute of Standards and Technology, Gaithersburg, MD, <sup>2</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany, <sup>3</sup>Graduate Institute of Applied Physics, National Taiwan University, Taipei, Taiwan

## Graphene quantum Hall effect devices for AC and DC resistance metrology

**Mattias Kruskopf**<sup>1</sup>, Dinesh Patel<sup>2</sup>, Chieh-I Liu<sup>3</sup>, Albert Rigosi<sup>3</sup>, Rand Elmquist<sup>3</sup>, Yicheng Wang<sup>3</sup>, Stephan Bauer<sup>1</sup>, Yefei Yin<sup>1</sup>, Klaus Pierz<sup>1</sup>, Eckart Pesel<sup>1</sup>, Martin Goetz<sup>1</sup>, Schurr Jürgen<sup>1</sup>

<sup>1</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany, <sup>2</sup>Graduate Institute of Applied Physics, National Taiwan University, Taipei, Taipei, Taiwan, <sup>3</sup>National Institute of Standards and Technology, Gaithersburg, MD

## Crucial Steps to Realize a Graphene Quantum Hall Resistance Standard

**Jaesung Park**<sup>1</sup>, Dong-Hun Chae<sup>1</sup>, Dan Bee Kim<sup>1</sup>, Wan-Seop Kim<sup>1</sup>

<sup>1</sup>Korea Research Institute of Standards and Science (KRISS), Daejeon, Daejeon, South Korea

## The EMPIR Project GIQS: Graphene Impedance Quantum Standard

**Luca Callegaro**<sup>1</sup>, Vincenzo D'Elia<sup>1</sup>, Martina Marzano<sup>1</sup>, Ngoc Thanh Mai Tran<sup>2</sup>, Massimo Ortolano<sup>2</sup>, Jan Kučera<sup>3</sup>, Klaus Pierz<sup>4</sup>, Stephan Bauer<sup>4</sup>, Mattias Kruskopf<sup>4</sup>, Yefei Yin<sup>4</sup>, Yaowaret Pimsut<sup>4</sup>, Felicien Schopfer<sup>5</sup>, Olivier Thevenot<sup>5</sup>, Blaise Jeanneret<sup>6</sup>, Frederic Overney<sup>6</sup>, Tobias Bergsten<sup>7</sup>, Antti Manninen<sup>8</sup>, Jaani Nissilä<sup>8</sup>, Dong-Hun Chae<sup>9</sup>

<sup>1</sup>Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy, <sup>2</sup>Politecnico di Torino, Torino, Piedmont, Italy, <sup>3</sup>Czech Metrology Institute, Brno, Czech Republic, <sup>4</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany, <sup>5</sup>Laboratoire national de métrologie et d'essais (LNE), Trappes, Yvelines, France, <sup>6</sup>METAS, Bern-Wabern, Bern, Switzerland, <sup>7</sup>RISE Research Institutes of Sweden, Borås, Västra Götaland, Sweden, <sup>8</sup>VTT MIKES, Espoo, Finland, <sup>9</sup>Korea Research Institute of Standards and Science (KRISS), Daejeon, Daejeon, South Korea

## Precise evaluation of GaAs/AlGaAs 129 kΩ and 1 MΩ quantum Hall array devices for a quantum Wheatstone bridge

**Takehiko Oe**<sup>1</sup>, Rand Elmquist<sup>2</sup>, Dean Jarrett<sup>2</sup>, Alireza R. Panna<sup>2</sup>, Nobu-Hisa Kaneko<sup>1</sup>, Yasuhiro Fukuyama<sup>1</sup>

<sup>1</sup>National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan, <sup>2</sup>National Institute of Standards and Technology, Gaithersburg, MD

## Uncertainty Evaluation for Liquid-Helium-Free Quantized Hall Resistance Measurement System at CMS

**Chou-Hsun Han**<sup>1</sup>, Shih-Fang Chen<sup>1</sup>, Jimmy C. Hsu<sup>1</sup>

<sup>1</sup>Center for Measurement Standards (CMS)/Industrial Technology Research Institute (ITRI), Hsinchu, Taiwan



## CPEM Virtual Technical Program

### RF and Microwave

#### Session: Antennas, Fields, and Materials

#### Reflectometer Calibration for Net Power Measurement and Uncertainty

Takehiro Morioka, National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan

#### Uncertainty Evaluation of Rydberg Atom-based RF E-field Metrology

Haiyang Zou<sup>1</sup>, Zhenfei Song<sup>2</sup>, Zhigang Feng<sup>2</sup>, Jie Zhang<sup>3</sup>, Jifeng Qu<sup>2</sup>

<sup>1</sup>Southeast University, Nanjing, Nanjing, China, <sup>2</sup>National Institute of Metrology (NIM), Beijing, China, <sup>3</sup>China Jiliang University, Hangzhou, Zhejiang, China

#### Microwave Field Detection via Autler-Townes Splitting and Temporal Oscillation in Rubidium Atomic Vapor

Zhenfei Song<sup>1</sup>, Zhigang Feng<sup>1</sup>, Haiyang Zou<sup>2</sup>, Xiaochi Liu<sup>1</sup>, Jifeng Qu<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China, <sup>2</sup>Southeast University, Nanjing, Nanjing, China

#### Standard Field Generation System for Calibration of Ka-band Electric Field Probe

No-Weon Kang<sup>1</sup>, Tae-Weon Kang<sup>1</sup>, Joo-Gwang Lee<sup>2</sup>, Young-Pyo Hong<sup>3</sup>, Jeong-Il Park<sup>1</sup>

<sup>1</sup>Korea Research Institute of Standards and Science (KRISS), Daejeon, Daejeon, South Korea, <sup>2</sup>Korea Research Institute of Standards and Science (KRISS), Daejeon, -, Korea, Republic of, <sup>3</sup>KRISS (Korea Research Institute of Standards and Science), Deajeon, -, Korea, Republic of

#### Measurement Uncertainty of Beam Parameters Induced by Imbalances of Amplitude and Phase for Antenna Array

Ke Liu<sup>1</sup>, Xin Bian<sup>1</sup>, Shaohua Wang<sup>1</sup>, Haining Zhao<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China

#### RF Energy Harvesting: Conducting an Urban and Suburban Outdoor Electromagnetic Site Survey

Nicolas Cobo<sup>1</sup>, Rogelio Palomera-Garcia<sup>1</sup>, Gladys O. Ducoudray-Acevedo<sup>1</sup>, Rafael . Rodríguez Solís<sup>1</sup>

<sup>1</sup>University of Puerto Rico, Mayaguez, PR

## **VNA-Based Material Characterization in THz Domain without Classic Calibration and Time-Gating**

**Alireza Kazemipour**<sup>1</sup>, Johannes Hoffmann<sup>1</sup>, Michael Wollensack<sup>1</sup>, Djamel Allal<sup>2</sup>, Martin Hudlicka<sup>3</sup>, Juerg Ruefenacht<sup>1</sup>, Daniel Stalder<sup>1</sup>, Markus Zeier<sup>1</sup>

<sup>1</sup>*METAS, Bern-Wabern, Bern, Switzerland*, <sup>2</sup>*Laboratoire national de métrologie et d'essais (LNE), Trappes, Yvelines, France*, <sup>3</sup>*Czech Metrology Institute, Prague, Czech Republic*

## **Performance Comparison Between Three Measurement System of Scanning Microwave Microscopy**

**Masahiro Horibe**<sup>1</sup>, Iku Hirano<sup>1</sup>

<sup>1</sup>*National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan*



## CPEM Virtual Technical Program

### RF and Microwave

#### Session: Network Parameters

#### Long-term stability test on on-wafer measurement system in NMIJ

Ryo Sakamaki<sup>1</sup>, Masahiro Horibe<sup>1</sup>

<sup>1</sup>National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan

#### GSSG-Probe Measurements with Increasing Dynamic Range through 15-Term Self-Calibration

Sebastian Wagner<sup>1</sup>, Reinhard Stolle<sup>1</sup>

<sup>1</sup>Hochschule Augsburg - University of Applied Sciences, Augsburg, Bavaria, Germany

#### Primary Standard of Attenuation in the Frequency Range of 1 kHz to 10 MHz

Anton Widarta, National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan

#### Nonlinear uncertainty propagation of on-wafer mixed-mode S parameter measurements using Multimode-TRL calibration

Djamel Allal<sup>1</sup>, François Ziadé<sup>1</sup>, Eric Bergeault<sup>2</sup>, Thi Dao Pham<sup>2</sup>

<sup>1</sup>Laboratoire national de métrologie et d'essais (LNE), Trappes, Yvelines, France, <sup>2</sup>Télécom Paris, Palaiseau, France

#### Automated Contacting of On-Wafer Devices for RF Testing

Faisal Mubarak<sup>1</sup>, Gert Rietveld<sup>1</sup>

<sup>1</sup>VSL B.V., Delft, Netherlands

#### VNA Linearity assessment with combinatorial method

Borut Pinter<sup>1</sup>, Klemen Stibernik<sup>2</sup>, Marko Berginc<sup>1</sup>, Miha Kokalj<sup>1</sup>

<sup>1</sup>SIQ Ljubljana, Ljubljana, Slovenia, <sup>2</sup>SIQ Ljubljana, Zagorje ob Savi, Zasavje, Slovenia





## CPEM Virtual Technical Program

### RF and Microwave

#### Session: Power and Noise

#### Noise Parameters Extraction with Special Source Reflection Coefficient Selection Patterns

He Chen<sup>1</sup>, Weijun Liang<sup>1</sup>, Hao Xu<sup>1</sup>, Qiulai Gao<sup>1</sup>, Zhijun Yang<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China

#### Digital Radiometer for Traceable Spectrum Sensing

Xifeng Lu<sup>1</sup>, Dazhen Gu<sup>1</sup>, Daniel Kuester<sup>1</sup>

<sup>1</sup>National Institute of Standards and Technology, Boulder, CO

#### Deposition of tantalum nitride films as the absorption load resistor for microwave power standard chips

Jian Chen<sup>1</sup>, Jinjin Li<sup>1</sup>, Huifang Gao<sup>1</sup>, Ying Gao<sup>1</sup>, Zheng Liu<sup>1</sup>, Qing Zhong<sup>1</sup>, Yuan Zhong<sup>1</sup>, Xiaolong Xu<sup>1</sup>, Xueshen Wang<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China

#### Comparison of Type-N Microcalorimeter Measurements among NIM, NMC and SCL

Xiaohai Cui<sup>1</sup>, Wenze Yuan<sup>1</sup>, Yu Song Meng<sup>2</sup>, Hau Wah Lai<sup>3</sup>, Steven Yang<sup>3</sup>, Brandon Wee Siong Lim<sup>2</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China, <sup>2</sup>National Metrology Centre, A\*STAR, Singapore, Singapore, Singapore, <sup>3</sup>Standards and Calibration Laboratory, Hong Kong, Hong Kong

#### Measurement of Thermoelectric Power Sensors Using a Thermal Voltage Converter of 1 kHz to 1 MHz

Tae-Weon Kang<sup>1</sup>, Jeong-Il Park<sup>1</sup>, Jeong Hwan Kim<sup>1</sup>, No-Weon Kang<sup>1</sup>

<sup>1</sup>Korea Research Institute of Standards and Science (KRISS), Daejeon, Daejeon, South Korea

#### Millimeter-Wave Power Standard Transfer Systems from 50 GHz to 330 GHz

Aditia N. Bakti<sup>1</sup>, Jae-Yong Kwon<sup>2</sup>, Chihyun Cho<sup>2</sup>, Hyunji Koo<sup>2</sup>

<sup>1</sup>University of Science and Technology, Daejeon, Daejeon, South Korea, <sup>2</sup>Korea Research Institute of Standards and Science (KRISS), Daejeon, Daejeon, South Korea

## **Novel Design of Water Bath-type Type-N Coaxial Microcalorimeter**

**Jae-Yong Kwon**<sup>1</sup>, Aditia N. Bakti<sup>2</sup>

<sup>1</sup>*Korea Research Institute of Standards and Science (KRISS), Daejeon, Daejeon, South Korea*, <sup>2</sup>*University of Science and Technology, Daejeon, Daejeon, South Korea*

## **Cryogenic Calibration of the RF Josephson Arbitrary Waveform Synthesizer**

**Justus Brevik**<sup>1</sup>, Alirio Boaventura<sup>1</sup>, Akim Babenko<sup>1</sup>, Manuel Castellanos-Beltran<sup>1</sup>, Nathan E. Flowers-Jacobs<sup>1</sup>, Anna Fox<sup>1</sup>, Peter Hopkins<sup>1</sup>, Paul Dresselhaus<sup>1</sup>, Dylan Williams<sup>1</sup>, Samuel Benz<sup>1</sup>

<sup>1</sup>*National Institute of Standards and Technology, Boulder, CO*





## CPEM Virtual Technical Program

### RF and Microwave

#### Session: Waveforms, Fast Pulses, and THz

#### International comparison on ultrafast waveform metrology

Mark Bieler<sup>1</sup>, Paul Struszewski<sup>1</sup>, Ari Feldman<sup>2</sup>, Jeffrey Jargon<sup>2</sup>, Paul Hale<sup>2</sup>, Pengwei Gong<sup>3</sup>, Wen Xie<sup>3</sup>, Chuntao Yang<sup>3</sup>, Zhigang Feng<sup>4</sup>, Kejia Zhao<sup>4</sup>, Zhijun Yang<sup>4</sup>

<sup>1</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany, <sup>2</sup>National Institute of Standards and Technology, Boulder, CO, <sup>3</sup>Beijing Institute of Radio Metrology and Measurement, Beijing, NA, China, <sup>4</sup>National Institute of Metrology (NIM), Beijing, China

#### Research on the traceability of pulse waveform parameters in NIM

Kejia Zhao<sup>1</sup>, Zhijun Yang<sup>1</sup>, Zhaochun Wu<sup>1</sup>, Zhigang Feng<sup>1</sup>, Difei Li<sup>1</sup>, He Chen<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China

#### Measurement of Terahertz Attenuation using a Photo-Acoustic Substitution Method

Hitoshi Iida<sup>1</sup>, Moto Kinoshita<sup>1</sup>

<sup>1</sup>National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan

#### Pulse waveform characterization by electro-optic sampling at NIM

Zhigang Feng<sup>1</sup>, Kejia Zhao<sup>1</sup>, Zhijun Yang<sup>1</sup>, Zhenfei Song<sup>1</sup>, Xiaohai Cui<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China

#### Photodiode Calibration Comparison between Electro-Optic Sampling and Heterodyne Measurements up to 75 GHz

Ari Feldman<sup>1</sup>, Jeffrey Jargon<sup>1</sup>, Paul Hale<sup>1</sup>, Tasshi Dennis<sup>1</sup>

<sup>1</sup>National Institute of Standards and Technology, Boulder, CO

#### Repeatable Phase Measurement of Millimeter-wave Modulated Signals using a VNA-based LO Phase Cancellation Technique

Yichi Zhang<sup>1</sup>, Meining Nie<sup>1</sup>, Lifeng Wang<sup>1</sup>, Zilong Zhang<sup>1</sup>, Zhao He<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China



## CPEM Virtual Technical Program

### RF and Microwave

#### Session: Other RF and Microwave

#### Calculable RF Standard for Frequencies Between 5 Hz and Several GHz

Johannes Hoffmann<sup>1</sup>, Markus Zeier<sup>1</sup>, Peter Huerlimann<sup>1</sup>, Juerg Ruefenacht<sup>1</sup>, Michael Wollensack<sup>1</sup>, Toai Le Quang<sup>1</sup>, Denis Vasyukov<sup>1</sup>

<sup>1</sup>METAS, Bern-Wabern, Bern, Switzerland

#### Theory and Demonstration of 1-port Vector Network Analyzer Calibration Technique Using Three Lines

Ryoko Kishikawa<sup>1</sup>, Masahiro Horibe<sup>1</sup>

<sup>1</sup>National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan

#### Two-Dimensional Visualization of Radio-Frequency Waves using Cesium Vapor Atoms

Moto Kinoshita<sup>1</sup>, Yuya Tojima<sup>1</sup>, Hitoshi Iida<sup>1</sup>

<sup>1</sup>National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan

#### On Propagation of Uncertainties through the Measurement Models of Two Calibration Methods for Microwave Power Splitters

Hau Wah Lai<sup>1</sup>, Cho Man Tsui<sup>1</sup>, Steven Yang<sup>1</sup>, Chi Kin Ma<sup>1</sup>

<sup>1</sup>Standards and Calibration Laboratory, Hong Kong, Hong Kong

#### Calibration of Electrical Fast Transient/Burst Generator in Accordance with IEC 61000-4-4 Edition 3.0 2012-04

Hau Wah Lai<sup>1</sup>, Cho Man Tsui<sup>1</sup>, Chi Kin Ma<sup>1</sup>, Steven Yang<sup>1</sup>

<sup>1</sup>Standards and Calibration Laboratory, Hong Kong, Hong Kong



## CPEM Virtual Technical Program

### Realization and Dissemination of the kg

#### Session: Kibble Balance I

#### Preparation for the OMOP Joule Balance

Lushuai Qian<sup>1</sup>, Jinxin Xu<sup>2</sup>, Zhengkun Li<sup>2</sup>, Wei Zhao<sup>1</sup>, Zhonghua Zhang<sup>2</sup>

<sup>1</sup>Tsinghua University, Beijing, Beijing, China, <sup>2</sup>National Institute of Metrology (NIM), Beijing, China

#### The Magnetization Effect in the Joule Balance with Compensation Coil

Jinxin Xu<sup>1</sup>, Lushuai Qian<sup>2</sup>, Zhengkun Li<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China, <sup>2</sup>Tsinghua University, Beijing, Beijing, China

#### Alignment in the MSL Kibble balance

Yin Hsien Fung<sup>1</sup>, Mark Clarkson<sup>1</sup>, Finn Messerli<sup>1</sup>

<sup>1</sup>Measurement Standards Laboratory of New Zealand, Lower Hutt, Wellington, New Zealand

#### The BIPM Kibble Balance: improvements and measurements

Hao Fang<sup>1</sup>, Franck Bielsa<sup>2</sup>, Adrien Kiss<sup>2</sup>, Michael Stock<sup>2</sup>

<sup>1</sup>BIPM, Sèvres, Hauts de seine, France, <sup>2</sup>BIPM, Sèvres, Hauts-de-Seine, France

#### A new interferometric system for the BIPM Kibble Balance

Franck Bielsa<sup>1</sup>, Hao Fang<sup>2</sup>, Adrien Kiss<sup>1</sup>, Michael Stock<sup>1</sup>

<sup>1</sup>BIPM, Sèvres, Hauts-de-Seine, France, <sup>2</sup>BIPM, Sèvres, Hauts de seine, France

#### Design of a New Dual-mode Torque Standard Machine That Operates on The Principle of the Kibble Balance

Myeonghhyeon Kim, Korea Research Institute of Standards and Science (KRISS), Daejeon, Daejeon, South Korea

#### AC Voltage Measurements in UME Kibble Balance

Hacı Ahmedov<sup>1</sup>, Beste Korutlu<sup>1</sup>, Recep Orhan<sup>1</sup>, Özlen Tuncel<sup>1</sup>

<sup>1</sup>TÜBİTAK UME, Gebze, Kocaeli, Turkey

#### Design of UME Kibble Balance-3

Hacı Ahmedov<sup>1</sup>, Beste Korutlu<sup>1</sup>, Recep Orhan<sup>1</sup>, Özlen Tuncel<sup>1</sup>, Cetin Dogan<sup>1</sup>

<sup>1</sup>TÜBİTAK UME, Gebze, Kocaeli, Turkey

## Local Vacuum in UME Kibble Balance

Hacı Ahmedov<sup>1</sup>, Beste Korutlu<sup>1</sup>, Recep Orhan<sup>1</sup>, Özlen Tuncel<sup>1</sup>, Neslihan Babayiğit Aşkın<sup>1</sup>  
<sup>1</sup>TÜBİTAK UME, Gebze, Kocaeli, Turkey



## CPEM Virtual Technical Program

### Realization and Dissemination of the kg

#### Session: Kibble Balance II

#### Abbe offset measurement in the NRC Kibble balance

Carlos Sanchez<sup>1</sup>, Barry Wood<sup>1</sup>

<sup>1</sup>National Research Council Canada, Ottawa, Ontario

#### Seasonal Effects in Gravity

Hacı Ahmedov<sup>1</sup>, Beste Korutlu<sup>1</sup>, Recep Orhan<sup>1</sup>, Özlen Tuncel<sup>1</sup>

<sup>1</sup>TÜBİTAK UME, Gebze, Kocaeli, Turkey

#### A Low-Cost Kibble Balance for Africa

Christoph Sonntag<sup>1</sup>, Aletta Karsten<sup>1</sup>, Thapelo Mametja<sup>1</sup>

<sup>1</sup>National Metrology Institute of South Africa (NMISA), Pretoria, Gauteng, South Africa

#### Measurement of the magnet system for the QEMMS

Rafael Marangoni<sup>1</sup>, Darine Haddad<sup>1</sup>, Frank C. Seifert<sup>1</sup>, Leon Chao<sup>1</sup>, David Newell<sup>1</sup>, Stephan Schlamming<sup>1</sup>

<sup>1</sup>National Institute of Standards and Technology, Gaithersburg, MD

#### Design of the Kibble balance for the QEMMS

Rafael Marangoni<sup>1</sup>, Darine Haddad<sup>1</sup>, Frank C. Seifert<sup>1</sup>, Leon Chao<sup>1</sup>, Jon Pratt<sup>1</sup>, David Newell<sup>1</sup>, Stephan Schlamming<sup>1</sup>

<sup>1</sup>National Institute of Standards and Technology, Gaithersburg, MD

#### Magnetization Effect in Kibble Balance Measurement

Shisong Li<sup>1</sup>, Stephan Schlamming<sup>2</sup>, Qing Wang<sup>1</sup>, Rafael Marangoni<sup>2</sup>, Darine Haddad<sup>2</sup>, Wei Zhao<sup>3</sup>

<sup>1</sup>Durham University, Durham, Durham, United Kingdom, <sup>2</sup>National Institute of Standards and Technology, Gaithersburg, MD, <sup>3</sup>Tsinghua University, Beijing, Beijing, China

#### Towards the next generation of NPL Kibble balances

Ian Robinson<sup>1</sup>, James Berry<sup>1</sup>, Christopher Bull<sup>1</sup>, Stuart Davidson<sup>1</sup>, Sven du Clou<sup>2</sup>, Charles Jarvis<sup>1</sup>, Henk Potgieter<sup>2</sup>, David Szwed<sup>1</sup>, Jeannie Urquhart<sup>1</sup>, Arthur Vie<sup>1</sup>, Emily Webster<sup>1</sup>, Perdi Williams<sup>1</sup>

<sup>1</sup>National Physical Laboratory, Teddington, Middlesex, United Kingdom, <sup>2</sup>National Metrology Institute of South Africa (NMISA), Pretoria, Gauteng, South Africa

## **Towards a table-top Kibble balance for E1 mass standards in a range from 1 mg to 1 kg – Planck-Balance 1 (PB1)**

**Christian Rothleitner**<sup>1</sup>, Shan Lin<sup>1</sup>, Frank Härtig<sup>1</sup>, Dorothea Knopf<sup>1</sup>, Norbert Rogge<sup>2</sup>, Suren Vasilyan<sup>2</sup>, Thomas Fröhlich<sup>3</sup>

<sup>1</sup>*Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany*, <sup>2</sup>*Technische Universität Ilmenau, Ilmenau, Thuringia, Germany*, <sup>3</sup>*TU Ilmenau, Ilmenau, Thüringen, Germany*

## **LNE Kibble balance progress report: modifications for vacuum operation**

Patrick Espel<sup>1</sup>, Djamel Ziane<sup>1</sup>, Florian Beaudoux<sup>1</sup>, Kamel Dougdag<sup>1</sup>, **Matthieu Thomas**<sup>1</sup>

<sup>1</sup>*Laboratoire national de métrologie et d'essais (LNE), Trappes, Yvelines, France*



## CPEM Virtual Technical Program

### Realization and Dissemination of the kg

#### Session: Si Crystal

#### Determination of Defect Concentrations in $^{28}\text{Si}$ Crystals Using EPR for the Realization of the Kilogram

Shigeki Mizushima<sup>1</sup>, Naoki Kuramoto<sup>1</sup>, Takahide Umeda<sup>2</sup>

<sup>1</sup>National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan, <sup>2</sup>Institute of Applied Physics,, Tsukuba, Ibaraki, Japan

#### Reproducibility of the Realization of the Kilogram Based on the Planck Constant by the XRCD method at NMIJ

Naoki Kuramoto<sup>1</sup>, Shigeki Mizushima<sup>1</sup>, Lulu Zhang<sup>1</sup>, Kazuaki Fujita<sup>1</sup>, Hajime Inaba<sup>1</sup>, Sho Okubo<sup>1</sup>, Yasushi Azuma<sup>1</sup>, Akira Kurokawa<sup>1</sup>, Yuichi Ota<sup>1</sup>, Kenichi Fujii<sup>1</sup>

<sup>1</sup>National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan

#### XPS analysis of a $^{28}\text{Si}$ -enriched sphere for realization of the kilogram

Lulu Zhang<sup>1</sup>, Naoki Kuramoto<sup>1</sup>, Akira Kurokawa<sup>1</sup>

<sup>1</sup>National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan

#### Uniformity Characterization of Lattice Spacing of $^{28}\text{Si}$ Single Crystals

Atsushi Waseda<sup>1</sup>, Xiao Wei Zhang<sup>2</sup>

<sup>1</sup>National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan, <sup>2</sup>Institute of High Energy Physics (IHEP), CAS, Beijing, Beijing, China

#### Volume Measurement of a $^{28}\text{Si}$ -enriched Sphere to Realize the Kilogram Based on the Planck Constant at NMIJ

Yuichi Ota<sup>1</sup>, Hajime Inaba<sup>1</sup>, Naoki Kuramoto<sup>1</sup>, Sho Okubo<sup>1</sup>

<sup>1</sup>National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan





## CPEM Virtual Technical Program

### Realization and Dissemination of the kg

Session: Other kg

#### Reliability Check of a Voltage Balance to Measure the Radiation Pressure for Small Mass and Force Standard at NMIJ

Kazuaki Fujita<sup>1</sup>, Kenichi Fujii<sup>1</sup>, Yasuyuki Yamamoto<sup>1</sup>, Yuichi Ota<sup>1</sup>, Naoki Kuramoto<sup>1</sup>

<sup>1</sup>National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan

#### The Recent Progress of the NIM-2 Joule Balance

Zhengkun Li<sup>1</sup>, Jinxin Xu<sup>1</sup>, Yang Bai<sup>1</sup>, Dawei Wang<sup>2</sup>, Lushuai Qian<sup>3</sup>, Qing He<sup>1</sup>, Zhonghua Zhang<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China, <sup>2</sup>Harbin Institute of Technology, Harbin, Heilongjiang Province, China, <sup>3</sup>Tsinghua University, Beijing, Beijing, China

#### Small mass realization in the new SI

Darine Haddad<sup>1</sup>, Patrick J. Abbott<sup>1</sup>, Leon Chao<sup>1</sup>, Edward Mulhern<sup>1</sup>, Frank C. Seifert<sup>1</sup>, Stephan Schlamming<sup>1</sup>, Zeina Kubarych<sup>1</sup>, David Newell<sup>1</sup>

<sup>1</sup>National Institute of Standards and Technology, Gaithersburg, MD



## CPEM Virtual Technical Program

Time, Optical, and Magnetics

Session: Magnetics

### Impedance of Helmholtz Coil to Generate Standard AC Magnetic Field in High Frequency

Masanori Ishii<sup>1</sup>, Mikiko Suzuki<sup>2</sup>

<sup>1</sup>National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan, <sup>2</sup>TOYOTA MOTOR CORPORATION, Toyota, Aichi, Japan

### DC Low Magnetic Field Standard System at KRISS

Sungjung Joo Joo<sup>1</sup>, Po Gyu Park<sup>1</sup>, Wan-Seop Kim<sup>1</sup>

<sup>1</sup>Korea Research Institute of Standards and Science (KRISS), Daejeon, Daejeon, South Korea

### A Characteristic Approximation Approach to Defect Edge Detection in Magnetic Flux Leakage Testing

Yue Long<sup>1</sup>, Songling Huang<sup>1</sup>, Lisha Peng<sup>1</sup>, Shen Wang<sup>1</sup>, Wei Zhao<sup>1</sup>

<sup>1</sup>Tsinghua University, Beijing, Beijing, China

### Measurement of thinning wall for ferromagnetic structures based on the reluctance of the magnetic circuit

Wenzhi Wang<sup>1</sup>, Wei Zhao<sup>1</sup>, Songling Huang<sup>1</sup>

<sup>1</sup>Tsinghua University, Beijing, Beijing, China

### A Simplified Calculation Model of MFL Signal of Defect Based on Lift-off Value

Lisha Peng<sup>1</sup>, Songling Huang<sup>1</sup>, Shen Wang<sup>1</sup>, Wei Zhao<sup>1</sup>

<sup>1</sup>Tsinghua University, Beijing, Beijing, China



## CPEM Virtual Technical Program

Time, Optical, and Magnetics

Session: Photonics and Optical Metrology

### Fresnel Reflection of Optical Fibres at Cryogenic Temperature for Absolute Radiometric Measurements

**Malcolm White**<sup>1</sup>, Esther Baumann<sup>1</sup>, Igor Vayshenker<sup>1</sup>, Zeus Ruiz<sup>2</sup>, Michelle Stephens<sup>1</sup>, John Lehman<sup>1</sup>  
<sup>1</sup>National Institute of Standards and Technology, Boulder, CO, <sup>2</sup>CENAM, Querétaro, Querétaro, Mexico

### Investigation of Superconducting Titanium films for Transition Edge Sensors

**Xiaolong Xu**<sup>1</sup>, Jinjin Li<sup>1</sup>, Xueshen Wang<sup>1</sup>, Qing Zhong<sup>1</sup>, Yuan Zhong<sup>1</sup>, Wenhui Cao<sup>1</sup>, Wei Li<sup>1</sup>, Jian Chen<sup>1</sup>, Zhiwei Zhao<sup>1</sup>, Ying Gao<sup>1</sup>, Zheng Liu<sup>1</sup>, Qing He<sup>1</sup>  
<sup>1</sup>National Institute of Metrology (NIM), Beijing, China

### Quantitative electro-optic measurements of ultrafast electrical signals on planar transmission lines: pitfalls and caveats

Paul Struszewski<sup>1</sup>, **Mark Bieler**<sup>1</sup>  
<sup>1</sup>Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Lower Saxony, Germany

### Electrical measurement capabilities of the cryogenic dual-mode optical power detector

**Marit U. Nordsveen**<sup>1</sup>, Eivind Bardalen<sup>2</sup>, Jarle Gran<sup>1</sup>  
<sup>1</sup>Justervesenet, Kjeller, Norway, <sup>2</sup>University of South-Eastern Norway, Borre, Vestfold og Telemark, Norway

### 1.5 $\mu\text{m}$ Wavelength Standard based on Acetylene Saturated Absorption at NIM

**Jianbo Wang**<sup>1</sup>, Cong Yin<sup>1</sup>, Jin Qian<sup>1</sup>, Chunying Shi<sup>1</sup>, Hanping Wang<sup>1</sup>, Shan Cai<sup>1</sup>, mingyu zhang<sup>1</sup>  
<sup>1</sup>National Institute of Metrology (NIM), Beijing, China



## CPEM Virtual Technical Program

### Time, Optical, and Magnetics

#### Session: Time and Frequency

#### Development of an operational Yb optical lattice clock towards contribution to the International Atomic Time

Takumi Kobayashi<sup>2</sup>, Daisuke Akamatsu<sup>2</sup>, **Kazumoto Hosaka**<sup>1</sup>, Yusuke Hisai<sup>1</sup>, Hajime Inaba<sup>1</sup>, Tomonari Suzuyama<sup>1</sup>, Feng-Lei Hong, Masami Yasuda

<sup>1</sup>National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki, Japan, <sup>2</sup>Department of Physics, Graduate School of Engineering Science, Yokohama National University

#### Systematic uncertainties in strontium optical lattice clocks

**Yannick Foucault**<sup>1</sup>, Bruno Ximenez Rodrigues Alves<sup>1</sup>, William Moreno<sup>1</sup>, Rodolphe Le Targat<sup>1</sup>, Jérôme Lodewyck<sup>1</sup>

<sup>1</sup>LNE-SYRTE, Observatoire de Paris, Paris, Ile de France, France

#### Progress of Compact CPT Rb Atomic Clock based on Grating Magneto-Optical Trap

**Junyi Duan**<sup>1</sup>, Xiaochi Liu<sup>1</sup>, Ning Ru<sup>1</sup>, Changling Zou<sup>2</sup>, Jifeng Qu<sup>1</sup>

<sup>1</sup>National Institute of Metrology (NIM), Beijing, China, <sup>2</sup>University of Science and Technology of China, Hefei, Anhui, China

#### The Official Time of Peru

**Henry J. Diaz Chonate**<sup>1</sup>, Michael Lombardi<sup>2</sup>

<sup>1</sup>Instituto Nacional de Calidad (INACAL), Lima, Lima, Peru, <sup>2</sup>National Institute of Standards and Technology, Boulder, CO

#### Analysis of dominant uncertainty comparing Monte Carlo and Taylor Series based methods in the tachometers calibration

**Nelson Bahamón**<sup>1</sup>, Liz Catherine Hernández Forero<sup>1</sup>, Claudia Fernanda Rodríguez<sup>1</sup>, Alexander Gutiérrez Guevara<sup>1</sup>

<sup>1</sup>Instituto Nacional de Metrología, Bogotá D.C., Bogotá D.C., Colombia