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## **Welcome Message from the Chairmen**

AMPS 2019, sponsored by the IEEE Instrumentation and Measurement Society and organized by the TC39 "Measurements in Power Systems", is the 10<sup>th</sup> edition of the IEEE International workshop on Applied Measurements for Power Systems.

This year, the 10<sup>th</sup> anniversary, AMPS workshop is moving back to its original location, at E.ON Energy Research Center RWTH, Aachen University, Aachen (Germany).

Building on its successful history, AMPS continues to represent a unique place for academia and industry to discuss measurement issues that are becoming more and more crucial in modern electric power systems, as confirmed by the continuous growing number of papers published on this subject and, above all, by the highest number of papers submitted this year to AMPS. The promotion of a fruitful interaction between all the relevant stakeholders is indeed the primary goal of the workshop, with the aim of exchanging knowledge, informing new research activities and facilitating the impact of research outcomes on present and future technology.

The papers presented in these proceedings have been divided into technical sessions dealing with energy meters, voltage and current sensors, measurements on railway systems, Phasor Measurement Units, measurements for smart grids, power system harmonics, frequency and ROCOF, uncertainty in power system measurements, State Estimation and measurements on power system components.

As usual, we hope this workshop will represent a qualified forum for highlighting problems, proposing solutions and, more in general, providing contributions to the advancement of the knowledge on these topics.

Welcome to AMPS 2019!

### **General Co-Chairs**

Prof. Carlo Muscas, *University of Cagliari, Cagliari, Italy*

Prof. Lorenzo Peretto, *University of Bologna, Bologna, Italy*

### **Technical Program Co-Chair**

Prof. Antonello Monti, *E.ON Energy Research Center RWTH Aachen University, Aachen, Germany*

## IEEE AMPS 2019 Organizers

### **General Chairs:**

Carlo Muscas, *University of Cagliari, Italy*

Lorenzo Peretto, *University of Bologna, Italy*

### **Technical Program Chairs:**

Antonello Monti, *E.ON Energy Research Center RWTH Aachen University, Germany*

### **Steering Committee:**

Mihaela Albu, *Politehnica University of Bucharest, Romania*

Julio Barros, *University of Cantabria, Spain*

Roberto Ferrero, *University of Liverpool, UK*

Alessandro Ferrero, *Polytechnic of Milano, Italy*

Ferdinanda Ponci, *E.ON Energy Research Center RWTH Aachen University, Germany*

Johan Rens, *North West University, South Africa*

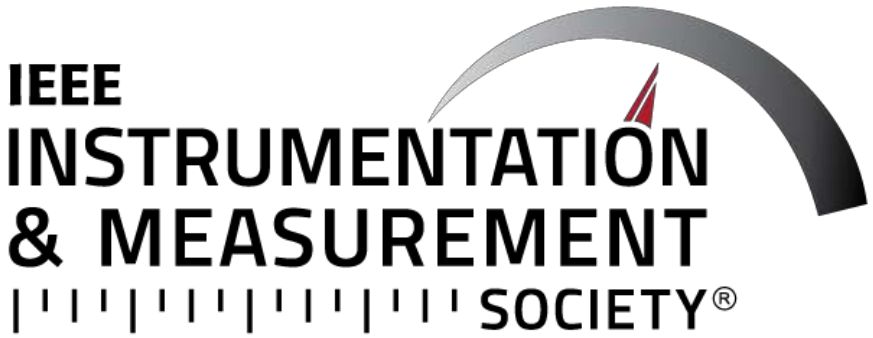
Sara Sulis, *University of Cagliari, Italy*

Roberto Tinarelli, *University of Bologna, Italy*

### **Conference Management:**

Conference Catalysts, LLC, USA

IEEE AMPS 2019 Sponsors



## Wednesday, September 25

**08:30 - 09:00**

**Registration**

**09:00 - 09:15**

**Welcome Address**

**09:15 - 09:30**

**Poster Presentation**

**09:30 - 11:00**

**Energy Meters**

**Room:** 0.24

**Session Chair:** Carlo Muscas (University of Cagliari, Italy)

**09:30**

***An Analysis of Customer Power Profile Events for Non-invasive Energy Meter Error Monitoring***

Zilvinas Nakutis (Kaunas University of Technology, Lithuania)

Stefano Rinaldi (University of Brescia, Italy)

Robertas Lukočius (Kaunas University of Technology, Lithuania)

Pranas Kuzas (Kaunas University of Technology, Lithuania)

**10:00**

***Current waveforms of household appliances for advanced meter testing***

Ronald van Leeuwen (VSL, The Netherlands)

Helko van den Brom (VSL, The Netherlands)

Dennis Hoogenboom (VSL, The Netherlands)

Gertjan Kok (VSL Dutch Metrology Institute, The Netherlands)

Gert Rietveld (VSL, The Netherlands)

**10:30**

***Testing of Electrical Energy Meters in Off-Nominal Frequency Conditions***

Alessandro Mingotti (University of Bologna, Italy)

Lorenzo Bartolomei (University of Bologna, Italy)

Roberto Tinarelli (University of Bologna, Italy)

Lorenzo Peretto (University of Bologna, Italy)

Diego Cavaliere (University of Bologna, Italy)

**11:00 – 11:30**

**Coffee Break**

**Room:** Foyer

## Wednesday, September 25

**11:30 – 13:00**

**Voltage and current sensors**

**Room:** 0.24

**Session Chair:** Sergio Toscani (Politecnico di Milano, Italy)

**11:30**

***A proposed method for evaluating the frequency response of 22 kV outdoor current transformers for harmonic measurements in renewable energy plant applications***

Ruan Murray (Hatch / North-West University, South Africa)

Jan de Kock (North West University, South Africa)

**12:00**

***A Simple Modelling Procedure of Rogowski Coil for Power Systems Applications***

Alessandro Mingotti (University of Bologna, Italy)

Lorenzo Peretto (University of Bologna, Italy)

Roberto Tinarelli (University of Bologna, Italy)

**12:30**

***Setup and Characterisation of Reference Current-to-Voltage Transformers for Wideband Current Transformers Calibration up to 2 kA***

Yeying Chen (National Metrology Institute of Germany (PTB), Germany)

Enrico Mohns (Scientist, Germany)

Henrik Badura (PTB, Germany)

Peter Raether (PTB, Germany)

Mario Luiso (University of Campania Luigi Vanvitelli, Italy)

**13:00 – 14:30**

**Lunch**

**Room:** Foyer

**14:30 – 16:00**

**Measurements on railway systems**

**Room:** 0.24

**Session Chair:** Roberto Tinarelli (University of Bologna, Italy)

**14:30**

***Behaviour of Spectral Active Power Terms for the Swiss 15 kV 16.7 Hz Railway System***

Andrea Mariscotti (ASTM, Switzerland)

**15:00**

***Monitoring Energy and Power Quality On Board Train***

Domenico Giordano (Istituto Nazionale di Ricerca Metrologica, Italy)

Davide Signorino (Istituto Nazionale di Ricerca Metrologica (INRIM), Italy)

Daniele Gallo (University of Campania Luigi Vanvitelli, Italy)

Mario Luiso (University of Campania Luigi Vanvitelli, Italy)

Gabriella Crotti (Istituto Nazionale di Ricerca Metrologica, Italy)

Antonio Delle Femine (University of Campania Luigi Vanvitelli, Italy)

Carmine Landi (University of Campania Luigi Vanvitelli, Italy)

Lorenzo Donadio (Trenitalia SpA, Italy)

Alfredo Biancucci (Trenitalia SpA, Italy)

## Wednesday, September 25

**15:30**

***Power Quality Event Analysis in 25 kV 50 Hz AC Railway System Networks***

Yljon Seferi (University of Strathclyde, United Kingdom (Great Britain))

Paul Clarkson (National Physical Laboratory, United Kingdom (Great Britain))

Steven Blair (University of Strathclyde, United Kingdom (Great Britain))

Andrea Mariscotti (ASTM, Switzerland)

Brian G Stewart (University of Strathclyde, United Kingdom (Great Britain))

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**16:00 – 16:30**

**Coffee Break**

**Room:** Foyer

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**16:30 – 17:30**

**Measurements for smart grids**

**Room:** 0.24

**Session Chair:** Lorenzo Peretto (University of Bologna, Italy)

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**16:30**

***The Characteristics of Smart Energy Information Management Systems for Built Environments***

Jagpreet Walia (Murdoch University, Australia)

Aridaman Walia (Murdoch University, Australia)

Christopher Lund (Murdoch University, Australia)

Ali Arefi (Murdoch University, Australia)

**17:00**

***An Experimental Characterization of Time of Arrival Accuracy for Time Synchronization of Medium Voltage Smart Grid Solutions***

Stefano Rinaldi (University of Brescia, Italy)

Federico Bonafini (University of Brescia, Italy)

Paolo Ferrari (University of Brescia, Italy)

Alessandra Flammini (University of Brescia, Italy)

Marco Pasetti (University of Brescia, Italy)

Emiliano Sisinni (University of Brescia, Italy)

Giovanni Artale (Università di Palermo, Italy)

Antonio Cataliotti (University of Palermo, Italy)

Valentina Cosentino (University of Palermo, Italy)

Dario Di Cara (National Research Council, Italy)

Nicola Panzavecchia (National Research Council, Italy)

Giovanni Tinè (National Research Council, Italy)

## Wednesday, September 25

09:00 – 17:30

Poster Session

Room: Foyer

### ***Effect of White Noise on Phase Estimation by Frequency Shifting and Filtering Algorithm***

Alessandro Mingotti (University of Bologna, Italy)

Lorenzo Peretto (University of Bologna, Italy)

Junhao Zhang (Hunan University, P.R. China)

Lu Tang (Hunan University, P.R. China)

Chengcheng Li (Hunan University, P.R. China)

He Wen (Hunan University & College of Electrical and Information Engineering, P.R. China)

### ***Real-Scenario Testing of an Active Phasor Data Concentrator***

Paolo Castello (University of Cagliari, Italy)

Carlo Muscas (University of Cagliari, Italy)

Paolo Attilio Pegoraro (University of Cagliari, Italy)

Asja Derviskadic (École Polytechnique Fédérale de Lausanne (EPFL), Switzerland)

Guglielmo Frigo (École Polytechnique Fédérale de Lausanne (EPFL), Switzerland)

Mario Paolone (Swiss Federal Institute of Technology of Lausanne (EPFL), Switzerland)

### ***A Flexible Real-Time Measurement and Control System for Enhanced In-Situ Battery Monitoring***

Chao Wu (University of Liverpool, United Kingdom (Great Britain))

Roberto Ferrero (University of Liverpool, United Kingdom (Great Britain))

### ***Design and Testing of a Setup for On-Site Power Measurements in High-Voltage Grids***

Gert Rietveld (VSL, The Netherlands)

Martin Fransen (VSL, The Netherlands)

Eddy So (National Research Council of Canada, Canada)

### ***Non-Invasive Wideband-frequency Grid Impedance Measurement Device***

Sriram Gurumurthy (EON Energy Research Center - RWTH Aachen University & Institute for Automation of Complex Power Systems, Germany)

Robert Uhl (RWTH Aachen University & Institute for Automation of Complex Power Systems, Germany)

Manuel Pitz (EON Energy Research Center - RWTH Aachen University, Germany)

Ferdinanda Ponci (RWTH Aachen University, Germany)

Antonello Monti (RWTH Aachen University & Institute for Automation of Complex Power Systems, Germany)

### ***Simplified Taylor-based Weighted Least Squares Synchrophasor Estimator for Harmonically Distorted Waveforms***

Daniel Belega (University of Timisoara, Romania)

Dario Petri (University of Trento, Italy)



## Thursday, September 26

**09:00 – 11:00**

**Phasor Measurement Units**

**Room:** 0.24

**Session Chair:** Mario Luiso (University of Campania Luigi Vanvitelli, Italy)

**09:00**

***Digital Filters for Phasor Measurement Units: Design Criteria, Advantages and Limitations***

David Macii (University of Trento, Italy)

Dario Petri (University of Trento, Italy)

**09:30**

***Three-Phase Synchrophasor Estimation Through Taylor Extended Kalman Filter***

Roberto Ferrero (University of Liverpool, United Kingdom (Great Britain))

Paolo Attilio Pegoraro (University of Cagliari, Italy)

Sergio Toscani (Politecnico di Milano, Italy)

**10:00**

***Step Change Detection Based on Analytic Signal for PMU Calibrators***

Marcelo Britto Martins (INMETRO, Brazil)

Paulo Antonio Andrade Esquef (LNCC, Brazil)

Renata Barros e Vasconcellos (Inmetro, Brazil)

**10:30**

***Impact of Fundamental Frequency Definition in IpDFT-based PMU Estimates in Fault Conditions***

Guglielmo Frigo (École Polytechnique Fédérale de Lausanne (EPFL), Switzerland)

Asja Derviskadic (École Polytechnique Fédérale de Lausanne (EPFL), Switzerland)

Mario Paolone (Swiss Federal Institute of Technology of Lausanne (EPFL), Switzerland)

**11:00 – 11:30**

**Coffee Break**

**Room:** Foyer

**11:30 – 13:00**

**Power system harmonics**

**Room:** 0.24

**Session Chair:** Steven Blair (University of Strathclyde, United Kingdom (Great Britain))

**11:30**

***A Robust Measurement Method for Supraharmonics Under Power Frequency Deviations***

Stefano Lodetti (Fundación CIRCE & Universidad de Zaragoza, Spain)

Victor Khokhlov (Technische Universität Dresden, Germany)

Jan Meyer (Technische Universität Dresden, Germany)

Jorge Bruna (CIRCE-Universidad de Zaragoza, Spain)

Julio J. Melero (Intituto Unversitario de Investigación Mixto CIRCE, Universidad de Zaragoza-

Fundación CIRCE, Spain)

## Thursday, September 26

**12:00**

***Assessment of the High Frequency Emissions of Low-Voltage Electronic Equipment Under Different Supply Conditions***

Adam Collin (University of Campania - Luigi Vanvitelli, Italy)  
Roberto Langella (University of Campania - Luigi Vanvitelli, Italy)  
Alfredo Testa (University of Campania - Luigi Vanvitelli, Italy)  
Mario Luiso (University of Campania Luigi Vanvitelli, Italy)  
Carmine Landi (University of Campania Luigi Vanvitelli, Italy)  
Antonio Delle Femine (University of Campania Luigi Vanvitelli, Italy)

**12:30**

***On harmonic pollution metering: field validation of index-based emission assessment***

Johan Rens (North West University, South Africa)  
Jan-Hendrik Hattingh (North-West University Potchefstroom Campus, South Africa)  
Sané Rens (North-West University, South Africa)

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**13:00 – 14:30**

**Lunch**

**Room:** Foyer

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**14:30 – 16:00**

**Frequency and ROCOF**

**Room:** 0.24

**Session Chair:** Paolo Attilio Pegoraro (University of Cagliari, Italy)

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**14:30**

***Proof of Concept for Three-Phase Extension of a Mains Frequency Estimation Algorithm***

Jan-Philipp Kitzig (Hochschule Ruhr West, Germany)  
Gerd Bumiller (Hochschule Ruhr West & University of Applied Sciences, Germany)

**15:00**

***Reference system for the identification and acquisition of power system frequency transients***

Marco Rossi (Ricerca sul Sistema Energetico & RSE, Italy)

**15:30**

***Requirements and Test Conditions for Reliable Rate-of-Change-of-Frequency Measurements***

Gert Rietveld (VSL, The Netherlands)  
Paul Wright (National Physical Laboratory, United Kingdom (Great Britain))  
Andrew Roscoe (Siemens-Gamesa Renewable Energy, United Kingdom (Great Britain))

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**16:00 – 16:30**

**Coffee Break**

**Room:** Foyer

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Thursday, September 26

**16:30 – 17:30**

**Uncertainty in power system measurements**

**Room:** 0.24

**Session Chair:** Dario Petri (University of Trento, Italy)

**16:30**

***Dealing with Definitional Uncertainty: Better Measurements in Power Systems***

Harold Kirkham (Pacific Northwest National Laboratory, USA)

D. White (Measurement Standards Laboratory of New Zealand, New Zealand)

Mihaela Albu (Politehnica University of Bucharest, Romania)

**17:00**

***Expressing Uncertainty of Voltage Transformers: A Proposal***

Marco Faifer (Politecnico di Milano, Italy)

Alessandro M Ferrero (Politecnico di Milano, Italy)

Christian Laurano (Politecnico di Milano, Italy)

Roberto Ottoboni (Politecnico di Milano, Italy)

Sergio Toscani (Politecnico di Milano, Italy)

Michele Zanoni (Politecnico di Milano, Italy)

## Thursday, September 26

09:00 – 17:30

Poster Session

Room: Foyer

### ***Effect of White Noise on Phase Estimation by Frequency Shifting and Filtering Algorithm***

Alessandro Mingotti (University of Bologna, Italy)

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Ferdinanda Ponci (RWTH Aachen University, Germany)

Antonello Monti (RWTH Aachen University & Institute for Automation of Complex Power Systems, Germany)

### ***Simplified Taylor-based Weighted Least Squares Synchrophasor Estimator for Harmonically Distorted Waveforms***

Daniel Belega (University of Timisoara, Romania)

Dario Petri (University of Trento, Italy)

20:00

Social Dinner

## Friday, September 27

**08:30 – 10:30**

**State Estimation**

**Room:** 0.24

**Session Chair:** Mihaela Albu (Politehnica University of Bucharest, Romania)

**08:30**

***A New Kalman Filter Approach Including System Frequency for an Effective PMU-based Power System State Estimation***

Carlo Muscas (University of Cagliari, Italy)

Paolo Attilio Pegoraro (University of Cagliari, Italy)

Sara Sulis (University of Cagliari, Italy)

Marco Pau (RWTH Aachen University, Germany)

Ferdinanda Ponci (RWTH Aachen University, Germany)

Antonello Monti (RWTH Aachen University & Institute for Automation of Complex Power Systems, Germany)

**09:00**

***Optimal Probabilistic PMU Placement in Electric Distribution System State Estimation***

Ali Arefi (Murdoch University, Australia)

Mahmoud-Reza Haghifam (Tarbiat Modares University, Iran)

Hamid Fathi (Amirkabir University of Technology, Iran)

Behnaz Behi (Murdoch University, Australia)

Ehsan Razavi (Murdoch University, Australia)

Philip Jennings (Murdoch University, Australia)

**09:30**

***Effect of latency on state estimation uncertainty***

Andrea Angioni (RWTH Aachen University, Germany)

Marco Pau (RWTH Aachen University, Germany)

Ferdinanda Ponci (RWTH Aachen University, Germany)

Antonello Monti (RWTH Aachen University & Institute for Automation of Complex Power Systems, Germany)

**10:00**

***The Impact of Loads Aggregation and Correlation in Distribution State Estimation***

Mehdi Shafiei (Lloyd's Register, Australia)

Amin MokariBolhassan (Queensland University of Technology, Australia)

Gerard Ledwich (Queensland University of Technology, Australia)

Ghavam Nourbakhsh (Queensland University of Technology, Australia)

Ali Arefi (Murdoch University, Australia)

**10:30 – 11:00**

**Coffee Break**

**Room:** Foyer

## Friday, September 27

**11:00 – 12:30**

**Measurements on power system components**

**Room:** 0.24

**Session Chair:** Antonello Monti (RWTH Aachen University, Germany)

**11:00**

***On the Use of Class B LoRaWAN for the Coordination of Smart Interface Protection Systems***

Marco Pasetti (University of Brescia, Italy)

Stefano Rinaldi (University of Brescia, Italy)

Emiliano Sisinni (University of Brescia, Italy)

Paolo Ferrari (University of Brescia, Italy)

Alessandra Flammini (University of Brescia, Italy)

**11:30**

***Approach to Wide-Frequency Battery Impedance Measurements in Commercial Applications***

Arne Sandschulte (University of Liverpool, United Kingdom (Great Britain))

Roberto Ferrero (University of Liverpool, United Kingdom (Great Britain))

Laurence Hardwick (University of Liverpool, United Kingdom (Great Britain))

Edoardo Patelli (University of Liverpool, United Kingdom (Great Britain))

**12:00**

***Challenge and future trends of distributed measurement systems based on Blockchain technology in the European context***

Fabrizio Ciancetta (University of L'Aquila, Italy)

Giovanni Bucci (Universita' Dell' Aquila, Italy)

Edoardo Fiorucci (University of L'Aquila, Italy)

Andrea Fioravanti (University of L'Aquila, Italy)

Alberto Prudenzi (University of L'Aquila, Italy)

Simone Mari (Università degli studi dell'Aquila, Italy)



