Symposium on "Wide area monitoring, and data-driven aspects for the future power systems"

Date: March 1, 2024 – 9:00 – 12:30h

Location: Lecture Hall Boole, Building 36, Mekelweg 4, 2628 CD Delft

Moderator: Dr. Jochen Cremer

Registration

The symposium " Wide area monitoring, and data-driven aspects for the future power systems" is held in celebration of the inauguration of Prof. Marjan Popov in the Department of Electrical Sustainable Energy. This symposium explores the latest advancements in power system monitoring and the management of transients in energy networks. Central to the discussions is the emphasis on Wide Area Monitoring Systems (WAMS) and their role in enhancing the operational stability and reliability of power grids, particularly in the context of increasing renewable energy integration. The speakers focus on how WAMS can effectively address the challenges posed by the fluctuating nature of renewable energy sources, focusing on maintaining frequency stability and managing network congestion. The application of these systems is crucial in ensuring that power networks can adapt to the dynamic and often unpredictable nature of modern energy landscapes. Additionally, the symposium highlights the importance of understanding and controlling electrical transients in power systems. It discusses advanced modeling techniques for simulating fault arcs and their interaction with the power network, particularly under various fault conditions. These models are instrumental in developing more effective strategies for system protection and in enhancing the overall resilience of the power grid.

After the symposium, the attendees are invited to join the inaugural speech 'Keeping the lights on – is our electricity grid secure?' by Prof. Marjan Popov (01 March 2024 15:00, Aula, TU Delft) Register

Agenda:

- 09:00 – 09:10 Opening (Cremer, Popov)
- 09:10 – 09:40 Prof. Vladimir Terzija
- 09:40 – 10:10 John William Wright
- 10:10 – 10:40 Dr. Sadegh Azizi
- *10:40 – 11:00 Coffee & tea break*
- 11:00 – 11:40 Prof. Alfredo Vaccaro
- 11:40 – 12:10 Prof. Mustafa Kizilcay

Speakers:

Vladimir Terzija, Professor of Energy Systems & Networks, Newcastle University, UK
Presentation: "Digitalization – a Revolution Leading to Future Low-Carbon Economies".

Vladimir Terzija received the Dipl-Ing., M.Sc., and Ph.D. degrees in electrical engineering from the University of Belgrade, Serbia. He is a Professor of Energy Systems & Networks at the Newcastle University, UK. He is also a Distinguished Professor at Shandong University, China, as well as a Guest Professor at the Technical University of Munich, Germany. In the past, he has been with the University of Belgrade (Serbia), ABB (Germany), The University of Manchester (UK) and Skoltech (Russian Federation). His research interests include smart grid applications; WAMPAC; power system protection; data analytics and the application of complex science for sustainable low-carbon energy systems. Prof. Terzija is Editor in Chief of the International Journal of Electrical Power and Energy Systems, Alexander von Humboldt Fellow, Fellow of IEEE, and the recipient of the National Friendship Award (China).

The shape of processes in the 21st century, particularly those related to technology, industry, and society, has been significantly changed. The introduction of smart technologies opened doors for designing and implementing smart solutions leading to secure, dependable, flexible, and resilient modern energy systems, which are considered one of the most critical factors determining future sustainable low-carbon economies. Newly designed concepts and demonstration projects of "digital substations", supported by cyber-secure communication channels, are enabling rapid, fast, and efficient transfer of data from the physical electricity network to hierarchically higher centers in which data are processed. The integration of physical elements of the power system with ICT creates a Cyber-Physical Power System consisting of a physical system strongly integrated with the cyber one. Through the application of data science-based solutions, the integration of renewable energy sources is maximized, and different energy vectors, e.g. electricity, heat, gas, transportation, or hydrogen, are integrated into single multi-energy systems, optimizing processes, making them more efficient and contributing to the transformation of existing energy systems into sustainable and low carbon systems. The abovementioned topics will be discussed from the new technology perspective, its impact on new solutions, and its expected benefits. Some representative practical examples will be presented, too.

John William Wright BEng (Hons) CEng FIET, Principal Engineer, Technical Applications Engineer Leader - Europe, Central Asia & Sub Saharan Africa, GE VERNOVA, Stafford, UK

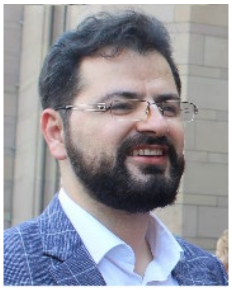
Presentation: “Application of Dynamic System Rating for Power Flow Optimization”.

John Wright received his BEng Honors Degree in electrical engineering from the University of Staffordshire, UK. He has over 30 years' of experience in the protection and control industry and expertise in areas such as R&D, product management, engineering design and application, commissioning, services, innovation, and digitization. Currently, he is Principal Engineer & Technical Applications Engineer Leader - Europe, Central Asia & Sub-Saharan Africa at GE VERNOVA. He is also a GE Senior Fellow, Institute of Engineering & Technology Fellow, Cigre B5 UK Regular Member, and Recipient of the Cigre B5 Technical Council Award.

The integration of high levels of Renewable Energy Capacity within existing electrical grids, which were designed to transmit power from conventional generation sources, has, in places, contributed to network congestion, and curtailment of renewable power and could potentially provoke voltage quality and stability issues. Whilst the transmission capacities of the network can be improved through the installation of new power lines, this may in many cases prove prohibitively expensive and time consuming. A principal constraining factor on network capacity is the thermal limit of the conductor and there has been widespread testing and implementation of both sensor-based and sensor-less Dynamic Line Rating technology which monitors the dynamic thermal rating of the line bases based on measurements of current, temperature, or sag.

However, the thermal limit is not the only limiting factor to network capacity, and dynamically increasing the rated capacities within the network could risk both the voltage and angular stability of the network. The use of Dynamic Line Rating technology alone is insufficient as a basis for autonomous control actions, more information is needed. This Lecture proposes monitoring of not only the thermal limits but also potential stability issues that may arise, by the parallel calculation of Dynamic Power Ratings for a local network zone. To utilize the additional power transfer capacity available and mitigate existing network congestion, control actions can be taken where controllable system elements are available. For these control actions to be effective, they need to be realized in very small latencies approaching real-time; the paper proposes a local approach to the required control actions, rather than rely on the centralized controls typically managing grid power flows.

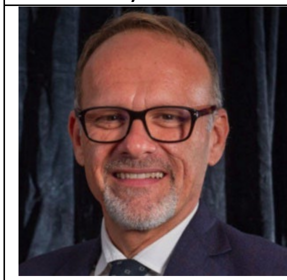
Sadegh Azizi, Lecturer in Smart Energy Systems, University of Leeds, Leeds, UK
Presentation: "Optimal Fast-Acting Frequency Containment in Modern Power Systems"



Sadegh Azizi received his Ph.D. degree from University of Tehran, Tehran, Iran in electrical engineering. He is currently a Lecturer in Smart Energy Systems with the School of Electronic and Electrical Engineering, University of Leeds, Leeds, U.K. From 2016 to 2019, he was with The University of Manchester as a Postdoctoral Researcher leading their work on the protection Work Package of the EU H2020 MIGRATE project, in collaboration with more than 20 European Transmission System Operators and research institutes. He was with the Energy and System Study Center, Monenco Iran Consulting Engineers Co., from 2009 to 2011, and the Iran's Electricity System Operator from 2013 to 2016. He is the Managing Editor of Elsevier's e-Prime and an Associate Editor for the International Journal of Electrical Power and Energy Systems. He is also a Task Leader of Cigré WG B5.57, which is investigating new challenges of frequency protection in modern power systems. His research interests include wide-area monitoring, protection and control systems, digital protective relays, and applications of power electronics in power systems.

The escalating penetration of renewable energy sources (RESs) into power systems is reducing the effectiveness of operation, control, and protection schemes traditionally employed. The decoupling of RESs' kinetic energy from the rest of the system and, thus, the variability of system inertia pose a critical challenge to maintaining frequency stability. In this talk, a new paradigm is introduced for optimal fast-acting frequency containment (OFFC) through a short yet targeted active power injection. This concept builds upon the innovative idea of decomposing frequency response into transient and steady-state deviations. The core aim of OFFC is to use WAMS to identify the size and location of loss of generation events, then reduce or completely remove the transient frequency deviation without unnecessarily changing the settling frequency. This is shown to minimize the time and efforts required to restore the frequency within the statutory limit while avoiding unnecessary expenditure of the turbines' lifetime. Only after allocating enough Energy resources for removing the transient deviation, system operators are advised to utilize Power resources to reduce the steady-state deviation. This strategic sequencing ensures an optimized utilization of resources and sustains a pragmatic balance between operational efficiency and economic considerations.

Alfredo Vaccaro, Professor in Electrical Engineering, University of Sanio, Italy
Presentation: "Toward decentralized and self-organizing Wide-Area Monitoring Protection And Control Systems".



Alfredo Vaccaro (Senior Member, IEEE) received the M.Sc. (Hons.) degree in electronic engineering from the University of Salerno, Salerno, Italy, and the Ph.D. degree in electrical and computer engineering from the University of Waterloo, Waterloo, ON, Canada. From 1999 to 2002, he was an Assistant Researcher with the Department of Electrical and Electronic Engineering, University of Salerno. From March 2002 to October 2015, he was an Assistant Professor of electric power systems with the Department of Engineering, University of Sannio, Benevento, Italy, where he is currently a Full Professor of electrical power systems. His research interests include soft computing and interval-based methods applied to power system analysis, and decentralized architectures for smart grid computing. He is an Associate Editor of IEEE Transactions on Power Systems and IEEE Transactions on Smart Grids and Chair of the IEEE PSOPE-T&I -Power System Operation, Planning and Economics- Technologies and Innovations Subcommittee.

The complexity of future smart grids and the expected high level of uncertainties in these networks might radically affect the required security and reliability of power systems' operations. In this context, Wide-area Monitoring Protection And Control Systems involve using system-wide information and communicating selected local information to a remote location to counteract the propagation of large disturbances and reduce the probability of potential catastrophic blackouts. It is expected that WAMPACs will sensibly improve the reliability and security of energy production, transmission, and distribution, particularly in power networks with high operational uncertainties. To realize these benefits, researchers and designers of high-performance WAMPACs are revisiting numerous design issues and assumptions about scale, reliability, heterogeneity, manageability, and system evolution over time.

Following these research directions, this talk outlines the important role of cooperative and self-organizing sensor networks in smart grid computing, analyzing the possibility of decentralizing the WAMPACs processing and synchronization functions on a network of interactive smart units equipped with distributed consensus protocols. Detailed simulation studies are presented and discussed to assess the effectiveness of this computing and synchronization paradigm.

Senior Mustafa Kizilcay, Professor, Department of Electrical Eng. and Computer Science, Chair of Electrical Power Systems, University of Siegen, Siegen, Germany

Presentation: "Digital Simulation of Fault Arcs in Electrical Power Networks"

Mustafa Kizilcay was born in Bursa, Turkey in 1955. He received the B.Sc. degree from Middle East Technical University of Ankara in 1979, "Dipl.-Ing." degree and Ph.D. degree from University of Hannover, Germany in 1985 and 1991. From 2004 until end of 2022 he has been with the University of Siegen, Germany, holding the Chair for Electrical Power Systems as full professor in the Department of Electrical Engineering and Computer Science. Prof. Kizilcay is winner of the annual publication prize of the Power Engineering Society of German Electrial Engineers Association (ETG-VDE) in 1994. His research fields are power system analysis, digital simulation of power system transients and dynamics, insulation-coordination and protection. Prof. Kizilcay is senior member of IEEE, member of CIGRE, VDE and VDI in Germany.

A suitable dynamic arc model is capable of investigating the interaction of the fault arc burning freely in the air with the electric circuit during line-to-ground faults. The arc model should indicate whether the arc will sustain or extinguish depending on the power system voltage level and the arc suppression measure applied at that voltage level. In an EHV transmission system, the single-phase autoreclosure (SPAR) is the effective means to eliminate arc faults without endangering the stability of the system. Therefore it is important to set an optimum dead time for the SPAR so that it is sufficiently long to guarantee the extinction of the secondary arc and it is short enough not to risk the system stability. In so-called resonant-earthed MV systems, the arc suppression coil (so-called Peterson coil) connected between the neutral point of a transformer and the local earth compensates during a line-to-ground fault the capacitive component of the fault current. If the coil is well tuned, the earth fault current becomes minimum resulting in rush extinction of the fault arc. Since the fault current is sufficiently low and the arc in air extinguishes quickly, there is no protective provision against earth faults in resonant-earthed MV systems. An "universal" arc model should be capable of replicating the physical phenomenon, i. e. the interaction of the arc with the power network.

In this lecture, the fundamentals of the developed universal fault arc model will be described and the performance of the model will be illustrated using simulations of the electromagnetic transients that occur during a fault. The simulation results have been compared with the field measurements which reveal a good agreement between simulation and measurement.