

Tutorial #19 for Sunday Afternoon

Tutorial Title:

Smart Transformer: achieving high power flexibility in future electrical grids

Instructor Team:

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Abstract:

The electrical grid is moving toward a 100% integration of power electronics-based resources for generation (e.g., renewables), loads (e.g., electric vehicles), and storage (e.g., batteries). This allows a better usage of green energy and a faster independence from fuel-based energy resources. This transformation to an electronic grid, however, requires faster actuators than classical electromechanical ones.

The Smart Transformer plays a central role in this transformation, being able to re-dispatch and optimally manage the energy flow within the distribution grid. As a power electronics-based transformer, it not only transforms the voltage level from MV to LV grids, but it allows a dynamic interaction with the connected grid, as it will be shown in this tutorial for different scenarios. In order to exploit its capability, the Smart Transformer requires combining power system aspects and power electronics constraints, resulting in new requirements and challenges.

This tutorial introduces the Smart Transformer concept and takes into account power system considerations as well as power electronics knowledge. Main topics that will be addressed in this tutorial will regard the scenarios and business cases, where the Smart Transformer plays a key role (e.g., electric vehicle charging stations, harbor and airport infrastructures), Smart Transformer architectures and topologies, basic controller designs and innovative concepts for increasing the power flexibility in distribution grids, and standards for the grid integration.

The Project will summarize the results of ten years work of German and international experience. Contributions from IEEE PES Task Force, IEEE Standard working group P3105 and CIGRE WG B4.91 will be included, in order to provide to participants the latest news in terms of standardization and grid integrations of smart transformers.

Instructor Biographies:

Giovanni De Carne received the M.Sc. degree in electrical engineering from the Polytechnic University of Bari, Italy, in 2013, and the Ph.D. degree from the Chair of Power Electronics, Kiel University, Germany, in 2018. Since Nov. 2022 he is Tenure-Track W1 Professor at the Institute for Technical Physics at the Karlsruhe Institute of Technology, head of the "Real Time System Integration" Group and head of the "Power Hardware In the Loop Lab". He has authored/coauthored more than 70 peer-reviewed scientific

papers. His research interests include power electronics transformers, real time modelling, and power- and hardware-in-the-loop testing. He is an Associate Editor of the IEEE Industrial Electronics Magazine and IEEE Open Journal of Power Electronics. He held several tutorials at international conferences (ECCE, ECCE Asia, PowerTech, ISGT Europe) on the Smart Transformer applications and power electronics modelling topics. He is the General Chair of the IEEE PELS and PES "Electronic Grid (eGrid) Workshop 2023" to be held in October 2023 in Karlsruhe, Germany, and he was the technical committee chairman for the IEEE 2022 PEDG conference, held in June 2022 in Kiel, Germany.

Marco Liserre received the MSc and PhD degree in Electrical Engineering from the Bari Polytechnic, respectively in 1998 and 2002. He has been Associate Professor at Bari Polytechnic, and from 2012 Professor in reliable power electronics at Aalborg University (Denmark). From 2013 he is Full Professor and he holds the Chair of Power Electronics at Kiel University (Germany). At Kiel University, he is leading a team of 25 researchers having responsibility role, within the strategic governmental 10 years' initiative "Copernicus" in Germany for the Energy Change towards 80 % renewable based energy society and in two priority programs of the German research Foundation DFG. He will be leading the research group "Electronic Energy Systems" at Fraunhofer ISIT, which will employ 20 researchers.

Notably he has been awarded in 2013 with an ERC Consolidator Grant (European Excellence Grants) for the project "The Highly Efficient And Reliable smart Transformer (HEART), a new Heart for the Electric Distribution System". He has published more than 600 technical papers (1/3 of them in international peer-reviewed journals) and a book. These works have received more than 35000 citations. Marco Liserre is listed in ISI Thomson report "The world's most influential scientific minds" from 2014. He is Fellow of IEEE and member of IAS, PELS, PES and IES. He has been serving all these societies in different capacities. He has received the IES 2009 Early Career Award, the IES 2011 Anthony J. Hornfeck Service Award, the 2014 Dr. Bimal Bose Energy Systems Award, the 2011 Industrial Electronics Magazine best paper award in 2011 and 2020 and the Third Prize paper award by the Industrial Power Converter Committee at ECCE 2012, 2012, 2017 IEEE PELS Sustainable Energy Systems Technical Achievement Award the 2018 IEEE-IES Mittelman Achievement Award, which is the highest award of the IEEE-IES and the Istvan Nagy 2022 Award (EPE-PEMC Council).

Marius Langwasser received the M.Sc. and Ph.D. degrees from Kiel University, Kiel, Germany, in 2016 and 2021, respectively. He is currently a Senior Post-Doctoral Scientific Staff Member and the Leader of the Group "Hybrid Grids," Chair of Power Electronics, Kiel University. He is responsible for the Kopernikus-project ENSURE and Marie Skłodowska-Curie Research Actions Wingrid and SMARTGySum. His research interests include control and protection of meshed and hybrid grids, dynamically reconfigurable grids and grid service provision with high-voltage direct current (HVdc) systems and smart transformers.

Felix Wald received his bachelor's degree from Berlin University of Applied Sciences in 2019 and his master's degree from the Karlsruhe Institute of Technology in 2021, in electrical engineering. Since February 2021 he is working towards his Ph.D. degree as part of the "Real Time System Integration" group and "Power Hardware-in-the-Loop" lab at the Institute for Technical Physics at the Karlsruhe Institute of Technology, Karlsruhe, Germany. He is an active member of the IEEE PES Taskforce on Solid State Transformer integration in distribution grids and his research interests include Power Hardware-in-the-Loop validation and the technical and economic investigation of power electronic transformers.