TUTORIAL TITLE

EV Charging Technologies:

Power Electronics and Quality

Name(s) and Affiliation(s) of the Lecturer(s):

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Tutorial Objectives:

lectric vehicles have been booming for years. They are crucial for achieving the European Union's CO2 emission goal by 2050, as well as bringing exciting driving experiences which in the past were only with luxury fossil fuel cars. EV chargers, as an interface between the electric grid and the power battery in the vehicles, influence both sides. On-board or off-board chargers are essentially power electronics systems, which bring a lot of flexibility and controllability to bridge the grids and batteries. Meanwhile, they can also create problems for both sides if not properly designed. This tutorial will discuss the latest power electronics technologies in EV charging, in terms of configurable topology design and advanced modulation schemes, to tackle the variable battery voltage during charging/discharging, and the supraharmonics injected into the grid. Additionally, the tutorial will focus on dynamic modelling and control of the EV chargers. Specifically, a grey-box impedance modelling approach without requiring control details of the chargers will be presented. It inherits the advantage of both analytical modelling and black-box measurement. Secondly, with the knowledge of the impedance model, a controller tuning approach will be presented to ensure the small-signal stability of EV chargers' grid connection, no matter the high or low short circuit ratio (SCR).

Target Audience:

The tutorial will be given in the format of a traditional lecture. Anyone from industry or academia working on EV charging or power quality is the targeted audience.

Topical Outline:

1. Introduction
   - AC & DC chargers
   - Standards and requirements
   - Technical trends

2. Theme 1 - Power conversion techniques
   - Configurable topologies
   - Advanced modulation schemes

3. Theme 2 – Gray-Box impedance modelling
   - Control structure recognition via impedance curve pattern
   - Parameter identification via gradient descent optimization
   - Implementation

4. Theme 3 – Analytic controller tuning
   - Root cause of the small signal instability of a grid-charger system
   - Approximation of resonance frequencies and the maximum non-passive frequencies

5. Conclusions

Provisional Schedule of the Tutorial:

Schedule:

09:00 - 10:20 : Introduction / Theme 1
10:20 - 10:40 : Coffee break
10:40 - 12:15: Theme 2/ Theme 3 / Conclusions/Q&A

About the Lecturers:

Zian Qin (IEEE Senior Member) received the B.Sc. degree from Beihang University, Beijing, China, in 2009; M.Sc. degree from Beijing Institute of Technology, Beijing, China, in 2012; and Ph.D. degree from Aalborg University, Aalborg, Denmark, in 2015; all in electrical engineering.

He is currently an associate professor with the Department of Electrical Sustainable Energy, Delft University of Technology, the Netherlands. In 2014, he was a Visiting Scientist at RWTH Aachen University, Aachen, Germany. His research interests include power quality and stability of power electronics-based grids, solid-state transformers, and battery energy storage. He has more than 100 journals/conference papers, 4 book chapters, and 2 international patents, and he has worked on several European, Dutch national and industrial projects in these areas.

He is the founding chair of the IEEE Benelux Section Transportation Electrification Council Chapter, and the Dutch national representative in

Cigre Working Group B4.101 on grid-forming energy storage systems. He is an associate editor of IEEE Trans Industrial Electronics and IEEE Journal of Emerging and Selected Topics. He is a Distinguished Reviewer for 2020 of IEEE Transactions of Industrial Electronics. He served as the technical program chair of IEEE-PEDG 2024, IEEE-PEDG 2023, IEEE-ISIE 2020, IEEE-COMPEL 2020, etc. He is the winner of the Excellent Innovation Award, 2nd Place, in the IEEE International Challenge in Design Methods for Power Electronics.

Lu Wang (IEEE Graduate Student Member) received the B.Sc. degree in Electrical Engineering from the Beijing Institute of Technology, Beijing, China, in 2015, the M.Sc. degree (cum laude) in Electrical Power Engineering from Delft University of Technology, Delft, The Netherlands, in 2018, where he is currently pursuing the Ph.D. degree with the DC Systems, Energy Conversion and Storage group on Power Quality of EV Charing.

Since 2024, he has been a Research Scientist at Hitachi Energy, Västerås, Sweden. From 2019 to 2020, He was a hardware engineer at Prodrive Technologies B.V., Son, The Netherlands. His research interests include power quality and the stability of power-electronics-based systems.