Tutorial Proposal

1. Tutorial Title

EV charging technologies

2. Instructor Team: name(s), affiliation(s), and contact information

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3. Abstract

Electrification of mobility plays an important role in the roadmap towards a carbon-neutral climate by 2050 in Europe and North America and 2060 in Asia. Chargers, on the one hand, determine the charging time and thereby the user experience, and on the other hand, have a significant impact on the grid, thus becoming a critical technology that has received immense attention in both industry and academia.

EV charging is categorized into four modes, standardized in IEC 61851-1. As the power level increases, the charger configuration changes from single-phase AC to three-phase AC, and eventually DC. When the power level is low, the charger is light enough to be installed in the EV (on-board charger). Nevertheless, when the power level is high, the charger is bulky and heavy and is not appropriate to be carried by an EV all the time. Thus, it is installed in the charger (off-board charger). Then the output of the charging pile is actually the output of the off-board charger, which is DC. An off-board charger is also called a DC charger.

For charging power around hundreds of kW, the charging cable needs liquid cooling and becomes heavy and expensive. Contactless charging is a promising technology to eliminate the charging cable and plug. Additionally, it also enables charging in motion. Contactless power transfer includes capacitive and inductive ones, where the latter is considered to be more promising for contactless EV charging. An inductive contactless charger has a power conversion structure similar to the on-/off- board charger, but the charger is split into two parts separated by the isolation transformer, and the transformer is replaced by two charging panels with coil and magnetic core. One charging panel is on-board, while the other is off-board.

The installation of chargers - both low and high power, is increasing dramatically, under colossal market demand. Whether the operation of our grid infrastructure is robust enough to handle this large amount of integration is still a question mark. In fact, a few power quality (PQ) issues in terms of voltage imbalance, flicker, harmonics, supraharmonics, etc., have already been reported, which are associated with the high power EV chargers nearby.

The primary layer control of the EV charging is the charging current/voltage control. On top of that, the whole charging process can be controlled (not yet implemented in most chargers, but the current charging infrastructure is capable of doing it) in terms of ramping up/down time, charging power, charging time window, etc. A series of intelligent control for the above-mentioned objective is called smart charging, which has the potential to increase the utilization rate of grid infrastructure, reduce the charging cost with the flexible price of electricity, increase the efficiency in power transfer, reduce grid impact, increase the system autonomy especially when renewables are integrated to the charging station, etc. A unique application of smart charging is bidirectional charging, referred to as vehicle-to-grid, where the energy from the EV battery can be discharged as well. It opens the opportunity for the EV battery to be used as an energy storage device. A key point of attention is the effect that uncontrolled, smart, and fast charging has on the EV battery and its lifetime.

In this tutorial, more details are elaborated in terms of topologies and control of on-/off-board chargers, contactless charging, power quality of EV charging, renewables integration in charging station, smart charging – V2G, and effect on battery degradation.

4. Tutorial Outline

1. Introduction (Pavol, 20 mins)
2. Theme 1 - Power electronic circuits of EV charging (70 mins)
   - On-board charger (Zian, 15 mins)
   - Off-board charger (Zian, 15 mins)
   - Contactless charger (Jianning, 40 mins)
3. Theme 2- Power quality of EV charging (Zian, 40 mins)
   - Power quality issues
   - IEEE, IEC standards
   - Current practices and challenges
4. Theme 3- Smart charging (Gautham, 40 mins)
   - Smart charging and its implementation
   - Charging EVs from solar energy
   - V2G and use of EV as a storage
   - Effect of EV charging on battery lifetime
5. Conclusion (Pavol, 10 mins)

Schedule:

08:30-10:00: Introduction/Theme1
10:00-10:20: Coffee break
10:20-11:50: Theme2/Theme3/conclusion
11:50-12:10: Q&A

5. Lecture Style and Requirements

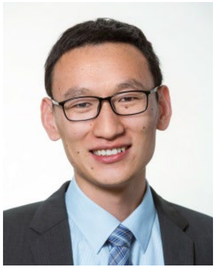
This tutorial would be a traditional lecture and would interact with audiences through Q&A

6. Instructor Biography

Pavol Bauer is currently a full Professor with the Department of Electrical Sustainable Energy of Delft University of Technology and head of DC Systems, Energy Conversion and Storage group. He received Masters in Electrical Engineering at the Technical University of Kosice (a85), Ph.D. from Delft University of Technology (a95) and title prof. from the president of Czech Republic at the Brno University of Technology (2008) and Delft University of Technology (2016). He published over 72 journal and almost 300 conference papers in his field (with H factor Google scholar 43, Web of science 20), he is an author or co-author of 8 books, holds 4 international patents and organized several tutorials at the international conferences. He has worked on many projects for industry concerning wind and wave energy, power electronic applications for power systems such as Smarttrafo; HVDC systems, projects for smart cities such as PV charging of electric vehicles, PV and storage integration, contactless charging; and he participated in several Leonardo da Vinci and H2020 EU projects as project partner (ELINA, INETELE, E-Pragmatic) and coordinator (PEMCWebLab.com-Edipe, SustEner, Eranet DCMICRO).

Zian Qin is currently an Assistant Professor at Delft University of Technology, Delft, Netherlands. He received his B.Eng. degree in Automation from Beihang University, Beijing, China, in 2009, M.Eng. degree in Control Science and Engineering from Beijing Institute of Technology, Beijing, China, in 2012, and Ph.D. degree from Aalborg University, Aalborg, Denmark, in 2015. In 2014, he was a Visiting Scientist at Aachen University, Aachen, Germany. From 2015 to 2017, he was a Postdoctoral Research Fellow at Aalborg University. His research interests include power quality and stability of power electronics-based grid, solid state transformers, and wide bandgap devices. He has published more than 90 journals/conference papers, 4 book chapters, and 2 international patents in these areas. He has also worked on several European and Dutch national projects regarding the power quality of wind farms and EV charging. He is leading the research on solid-state transformers in FlexH2.

He is an IEEE senior member, an associate editor of IEEE Trans Industrial Electronics, and a guest associate editor of IEEE Journal of Emerging and Selected Topics and IEEE Trans Energy Conversion. He is a Distinguished Reviewer for 2020 of IEEE Transactions of Industrial Electronics. He served as the technical program chair of IEEE-ISIE 2020, technical program co-chair of IEEE-COMPEL 2020, industrial session co-chair of ECCE-Asia 2020.



Jianning Dong received his B.S. and Ph.D. degrees in electrical engineering from Southeast University, Nanjing, China, in 2010 and 2015, respectively. Since 2016, he has been an Assistant Professor at the DC System, Energy Conversion and Storage (DCE&S) group, Delft University of Technology (TU Delft), Delft, The Netherlands. Before joining TU Delft, he was a Postdoctoral Researcher at McMaster Automotive Resource Centre, McMaster University, Hamilton, ON, Canada. His research interests include electromechanical energy conversion and contactless power transfer.

Gautham Ram is an Assistant professor of electric mobility in the DC systems, Energy conversion and Storage group in the Department of Electrical Sustainable Energy at the Delft University of Technology, The Netherlands. His current research focuses on electric vehicles, EV charging, PV systems, power electronics and demand-side management.

He received his bachelor's and master's in Electrical Engineering from the National Institute of Technology Trichy, India in 2011 and the Delft University of Technology in 2013, respectively. He received his PhD from Delft University in 2018 for the development of a solar-powered V2G electric vehicle charger compatible with CHAdeMO, CCS/COMBO and designed smart charging algorithms (with PRE Power Developers, ABB and UT Austin). From 2017 to 2019, he was a postdoctoral researcher at TU Delft working on research topics related to power converters for EV charging, smart charging of EVs, trolley busses.

He is involved in many projects with industrial and academic partners at national and EU level concerning electric mobility and renewable energy such as PV charging of electric vehicles, OSCD, Trolley 2.0, Flexgrid and Flexinet. He is the coordinator and a lecturer for Massive Open Online Course (MOOC) on Electric cars on edX.org with ~175,000 learners from 175 countries.