EPE'2021 – Tutorial Announcement

Safety considerations in Low Voltage DC Grids

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

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Scope and Benefits:

Low-voltage DC technology (LVDC) is emerging in several forms, thanks to evolutions in power electronics, e.g. in renewable energy systems based on photovoltaics and batteries, high-end drive systems, electrical vehicle charging systems. The advantages are higher efficiencies, ease and simplicity of installation yielding lower costs and improved reliability. On the other hand, in any DC system, protection requires specific attention, as common principles from AC technology cannot be applied. This tutorial aims to demonstrate the advantages of LVDC and addresses how protection can be handled in practice.

Contents:

The focus of courses on electrical safety typically only covers traditional AC systems. For DC systems, the protection methodologies that are used for AC cannot always be used. This is because Low Voltage DC (LVDC) grids are typically dominated by power electronics converters. As such, the protection methodology needs to be tuned to the lay-out of the grid and the used converters. For example, both the type of converter output capacitance and its size will strongly affect the short-circuit behavior of the LVDC grid. Multiple objectives are pursued: First, an overview of the state-of-the-art in LVDC systems and the advantages over AC for typical application areas is presented. Second, the typical faults and the fault behavior is discussed with an emphasis on the influence of the power electronics converters and the shortcomings in today's standards (e.g. IEC61660-1). Third, short-circuits are discussed, including fault detection, identification, localization and interruption. For the interruption, the typical problems related to arc extinction are treated and an overview of commercially available fuses and circuit breakers is given, including a short-circuit protection methodology. Fourth, earthing strategies, earth faults and the associated touch voltages will be discussed. Finally, practical considerations and emulating fault behavior is treated. The tutorial theoretical material will be supported by experimental results.

Topical Outline:

Introduction: (Estimated time: 30 minutes)

- Advantages of LVDC
- Typical applications
- Unipolar and bipolar grids
- Particularities of LVDC grids

Faults and fault behavior: (Estimated time: 60 minutes)

- Equipment protection
- Personal protection
- Arc-fault protection
- Faults in converter-dominated LVDC grids
- Shortcomings of standard IEC61660-1

Short-circuits Estimated time: 60 minutes)

- Fault identification
- Fault localization
- Fault interruption

Earth faults (Estimated time: 60 minutes)

- Grounding schemes
- Touch voltages
- Residual current breakers in LVCDC

Practical considerations (Estimated time: 60 minutes)

- Fault current calculations
- Fault emulator
- Datasheet gaps for correct calculations

Conclusions and wrap-up (Estimated time: 15 minutes)

Schedule:

	Monday, 6 September 2021 - Tutorial day (Virtual)
09:30 - 11:00	Tutorials Morning - Part 1: Introduction, faults and fault behaviour
11:00 - 11:30	Coffee break
11.30 - 13:00	Tutorials Morning - Part 2: Short circuits
13:00 - 14:00	Lunch break

14:00 - 15:30	Tutorials Afternoon - Part 3: Earth faults
15:30 - 16:00	Coffee break
16:00 - 17:30	Tutorials Afternoon - Part 4: Practical considerations, conclusions

Who should attend:

The tutorial aims to inform engineers active in the field of of LVDC grids or manufacturing devices and equipment featuring LVDC power supply. On the one hand, system designers will benefit as they will be provided with an overview on how to safely design an LVDC installation. On the other hand, also power electronic developers will benefit from understanding how their choices on converter level will impact the protection methodology. In principle, a basic background in electrical engineering is considered a sufficient prerequisite to attend this tutorial.

Technical Level:

In principle, a basic background in electrical engineering is considered a sufficient prerequisite to attend this tutorial.

About the Lecturers:

Johan Driesen received the MSc degree in 1996 as Electrical Engineer from the KU Leuven, Belgium. He received the PhD degree in Electrical Engineering at KU Leuven in 2000. In 2000-2001 he was a visiting researcher in the Imperial College of Science, Technology and Medicine, London, UK. In 2002 he was working at the University of California, Berkeley, USA. Currently, he is a full professor at the KU Leuven and teaches power electronics, renewables, drives and electromobility. He conducts research on distributed energy resources, including renewable energy systems, power electronics and its applications, for instance in renewable energy, storage and electric vehicles. Within EnergyVille, the research collaboration specializing in energy in smart cities and buildings, in cooperation with VITO and Imec, Johan Driesen is involved in the programmes on power electronics, distributed energy resources, electric vehicles and storage interfaces. Johan Driesen is also the programme director of the international master programmes in energy at KU Leuven and within the EIT-KIC InnoEnergy, a pan-European consortium supporting education and innovation in sustainable energy, the Education Director for the Benelux area.

Simon Ravyts received the M.Sc. degree in Energy - Electrical Engineering from KU Leuven, Leuven, Belgium in 2014, a second M.Sc. degree in Electrical Power Engineering from Ghent University, Gent, Belgium in 2016 and a Ph.D. degree at KU Leuven, Dept. of Electrical Engineering, EnergyVille. In his Ph.D., he investigates the integration of DC/DC converters in BIPV modules. His research interests include power electronics reliability, DC/DC converters and Low-voltage DC power distribution networks.

G. Van den Broeck (M'14) received the PhD degree in electrical engineering in 2019 (summa cum laude) and the MSc in electrical engineering (cum laude) in 2014 both at the University of Leuven, KU Leuven, Belgium. His PhD focused on control and protection aspects of bipolar DC distribution systems. His other research interests include power electronics for low- and medium-voltage DC distribution systems, microgrids, renewable energy and distributed energy resources. He is furthermore an active member in standardization bodies with respect to LVDC microgrids and founder of dcinergy. Dcinergy is an engineering company providing design support and developing (embedded) software platforms to facilitate the design and operation of LVDC grids, to foster their global and application-wide adoption.