Tutorial Title

HVDC Transmission Systems and DC Grids: Developments and Challenges (Two Parts).

Instructor Team

Dr Khaled H. Ahmed, University of Strathclyde, UK

Abstract

As large renewable power plants tend to be located far from consumption centers, integration of the power collected from these power plants represent a major challenge. For example, the electrical outputs of these renewable power plants could be DC or AC voltage with magnitude and frequency which are incompatible with that of the AC grids. Therefore, power electronic interfacing is needed to decouple the AC grids from the power plants, control active and power exchange with AC grid, and assist renewable power plants to ride-through different AC and DC network faults. The commercially available state-of-the- arts high voltage direct current (HVDC) link technologies are based on voltage source converters. However, most of the presently operational HVDC transmission systems are based on the thyristor line commutated current source converter technology that offers low semiconductor power loss and high power density, thanks to the robustness and high current capability of the thyristor in a single wafer capsules. On the other hand, thyristors inject significant low frequency harmonics into AC side, which must be eliminated by large passive filtering, and cannot decouple the control of reactive power from the active or DC power to be injected into the AC network. The use of large passive components leading to large footprint systems. Self-commutated voltage source converter HVDC transmission systems were developed to address the shortcomings associated with the line commutated current source converter based HVDC transmission systems. The tutorial aims to clarify the advantages and disadvantages of different HVDC technologies, i.e., LCC and VSC from the broader context of large power evacuation, HVAC grid support and renewable power generation and integration. The tutorial will cover integration of large renewable energy plants, including operation, control and interactions with AC grids. Also, interactions of current source converter (CSC) and voltage source converter (VSC) based HVDC with AC systems through controls and harmonics will be analyzed. AC and DC faults analysis for different HVDC technologies will be discussed. Finally, DC grids will be reviewed and discussed including the theoretical concepts, technology, control, faults, DC/DC embedded, and protection with particular emphasis on practical implementation aspects and on reported operational issues. For ease of illustration, the tutorial will be supported with simulations performed in MATLAB/SIMULINK.

Instructor Biography

Dr. Ahmed received his PhD degree from University of Strathclyde, UK in 2008. Currently, He is a Senior Reader in power electronics at the University of Strathclyde (PEDEC Group). He has a strong track record in high power electronics converters, and HVDC with 20+ years of experience in power electronics and energy conversion. He was a part of a 2-lecturer team who designed and delivered a continuing professional development (CPD) course on HVDC for the Scottish and Southern Energy (SSE) HVDC technology engineering team, UK. Dr Ahmed has published over 180+ technical papers in refereed journals and conferences, 1 book entitled *"High voltage direct current transmission: converters, systems and DC grids"*, Wiley-Blackwell, ISBN: 978-1-118-84666-7, 2015.', 1 book chapter, and a patent (PCT/GB2017/051364). Total citations of 5430 and h-index of 28. Two of his journal papers are rated in the top 1% of those cited in the academic field of Engineering (Web of Science). His income-funding portfolio to date is £5 million on projects funded by EPSRC, the EU, Innovate UK, KTP, the British Council, the Royal Society, the Scottish Funding Council, Net Zero Technology Centre, and industry (Rolls-Royce, BP, Shell, Equinor, Mitsubishi, Scottish Power, Scottish Power and Scottish and Southern Energy). Consultancy projects and research projects for a number of private sector companies have also been carried out such as Aker Solutions, Proven, Technip Umbilicals Ltd, and Scottish and Southern Energy (SSE). He has supervised/co-supervised 25 PhD students: 15 have graduated, and 10 are ongoing. He is a senior member of IEEE, IET member, Senior Fellow HEA and Chartered Engineer.