IEEE PES Transformers Committee
Spring 2021 Meeting
Online/Virtual

HVDC Tutorial 1: HVDC System Aspects (LCC and VSC)

— Technical Presentation —
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1. Abstract

High Voltage Direct Current (HVDC) transmission links have been in the market for more than 60 years. This is the selected application to transmit electricity over long distances (via overhead lines or DC cables) or connection of asynchronous AC systems. An HVDC link is controlled via semiconductor devices and the control features are often used to stabilize the connected AC networks, e.g. by power oscillation damping controllers, frequency controllers and AC voltage controllers.

Today, two main technical alternatives exist for HVDC:

- Line commutated converters (LCC), which use thyristors as semiconductors
- Voltage source converters (VSC), which use IGBTs as semiconductors

This tutorial has five parts. In the first part, Mr. Leslie Recksiedler will provide an overview of the different reasons for HVDC. Mr. Recksiedler will continue into part two to show different types of converter configurations, such as bipolar, symmetrical monopolar, asymmetrical monopolar and back-to-back. In the third part, Mr. Carsten Bartzsch will show different types of converter topologies, including LCC converter, VSC half bridge, VSC full bridge and hybrids. Mr. Pierre Riffon will take part four and show differences between LCC and VSC, including single line diagram, operation principles, performance and guarantees. In the fifth part, Mr. Ulf Radbrandt will present different system aspects regarding HVDC, including design criteria, calculations and simulations.

This tutorial will be followed by a second HVDC tutorial planned for the fall 2021 meeting. The second tutorial will cover HVDC equipment aspects for LCC and VSC.

2. Learning Objectives

This tutorial provides the following learning opportunities:

- Explain why HVDC is a natural choice for different transmission applications
- Show different transmission configurations and different converter topologies
- Explain the functionality and differences between LCC and VSC
- Explain the main system aspects for HVDC

3. Learning Outcomes

By attending this tutorial, attendees will gain an understanding of the following:

- General knowledge of HVDC technology
- Advantages with this technology compared to AC transmission links
- Factors affecting the design of HVDC transmission links

4. Presenters' Biographies

Dipl.-Ing. Carsten Bartzsch is the principal/lead engineer for HVDC Systems at Siemens Energy and is responsible for the technical design of Siemens HVDC projects. He has over 28 years of experience in power system and HVDC technology.

Carsten has been an active member of CIGRE Study Committee B4 DC Systems and Power Electronics over the past 20 years. In 2020, he received the CIGRE Technical Committee Award for his significant contribution to SC B4 as B4 German representative between 2010 and 2018 and one of the main contributing members of the strategic advisory group AG01 for many years as well as being an active participant and contributor to many CIGRE working groups. The German National Committee recognized his contributions in the areas of HVDC and FACTS with the Distinguished Member Award in 2020. Currently, he represents the German National Committee on the IEC TC115 HVDC transmission for DC voltages above 100 kV. Carsten received his Diplom-Ingenieur degree in Electrical Engineering from the Technical University Chemnitz, Germany in 1992.

Ulf Radbrandt joined ABB HVDC in 1991 in the control department as a designer and tester of software for different control applications. He moved to the system department in 1997 and was given technical responsibility for main circuit design, including system studies and specification of main circuit equipment, in 2002. He became the manager for main circuit equipment in 2011 and was promoted in 2017 to his current role as Manager of System Design and Simulation for Hitachi ABB Power Grids.

Ulf is a member of the IEEE Transformers Committee, where he is chair of the HVDC Converter Transformers and Smoothing Reactors Subcommittee. He also participates in a number of working groups. He received a University Certificate in Electrical Power Engineering from Mälardalens University in 1991 and a B.Sc. in Electrical Power Engineering from Dalarnas University in 2004.

Leslie Recksiedler is the senior engineering manager at PTC, a division of MHI. Les has worked on over 25 HVDC projects in 19 countries throughout the world, including over seven HVDC projects (mostly offshore wind) utilizing undersea cables, both AC and DC, plus several underground HVDC VSC projects with two projects in India. He worked on the Maritime HVDC link from specification to in-service as well as the Nelson River Bipoles 1 & 2 since 1975 and was the HVDC maintenance engineer for over 22 years. He was also involved in the O&M of the Songo Converter Station +/– 533 kV 1920 MW for Hydro Electric Cahora Bassa (HCB) in Mozambique, Africa for over 11 years. His over 40 years of experience in HVDC ranges from feasibility studies, apparatus design, technical and commercial specifications, bid reviews, contract negotiations, design reviews, factory acceptance testing, drawing approval for construction, installation supervision, pre-commissioning, commissioning, performance testing, as-built drawings, warranty, operations and maintenance, failure analysis, life assessment and asset management. He has extensive knowledge and experience in both LCC and VSC technologies, as well.

His many years of field experience and active involvement in international standards development have resulted in improvements to IEEE/IEC standards, CIGRE working groups and to technical specifications to improve reliability, availability and maintainability (RAM); increase the usable life of equipment and reduce operations and maintenance costs. Les was also the convener of CIGRE WG B4.54 Guidelines for Life Extension of Existing HVDC Systems and wrote a chapter on converter transformers for EPRI for life extension guidelines for HVDC Systems # 1012516. He is a Professional Engineer and has received a CIM (Gold Award in Business).

Pierre Riffon joined Hydro-Québec's Research Institute (IREQ) as a test engineer for the High Power Laboratory in 1980. From 1988 to 2013, he worked as a test specialist for Hydro-Québec's Quality Control Department and was responsible for type tests on high voltage substation equipment and special project apparatus, including static and series compensation and HVDC converters. Pierre retired from Hydro-Québec in 2013 and now works as an independent consultant for high voltage equipment testing. He is also currently associated with Englobe Corporation as a high voltage equipment principal engineer.

Pierre is a member of the IEEE Transformers Committee, on which he is participating in several subcommittees and working groups. In particular, he is Chairman of the working group on Test Requirements for Instrument Transformers for Nominal Voltage 115 kV and above and Chairman of the task force on Revision to Impulse Test Sections of IEEE C57.12.00 and IEEE C57.12.90. Pierre is also Vice Chairman of the Canadian IEC Technical Committee TC17 and Subcommittees SC17A and SC17C, Switchgear and Control Gear. He is the convener of a WG on high voltage alternating current by-pass switches and the Canadian representative on SC17A/MT36 for the revision of IEC 62271-100 High Voltage Circuit Breakers. He joined the Canadian IEC Technical Committee TC 14 on Transformers and is a member of MT 60076-5 on transformer short-circuit withstand testing. Pierre is a member of IEEE Power Engineering Society, CIGRE and registered as a Professional Engineer in the Province of Québec. He received his B.Sc.A. in Electrical Engineering from École Polytechnique de Montréal in 1980.