Guest Editorial
Advances in High Voltage DC Systems/Grids Control, Operation, and Protection

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High Voltage

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Interconnections between AC power systems, power transmission with higher efficiency, and aggregation and delivery of power from offshore wind farms to different AC regions are among the main drivers for the development of HVDC grids. HVDC grids can result in lower demand variability, higher flexibility, superior electricity market management, and higher economic value. It is expected that isolated HVDC systems transition to an HVDC grid that overlays the existing AC grid. Such a substantial development also results in a number of critical technical challenges related to system control, operation, and protection, which should be properly and accurately addressed. This Special Issue focuses on the recent achievements and advancements in overcoming these challenges. Accepted papers for publications in this Special Issue fall into four major topics: devices, control, operation, and protection.

Devices:

In the paper ‘Commutation overshoots based on a novel model for series thyristors during the turn-off process’ by Tang *et al*., first the turn-off models of independent thyristor and their applicability to series thyristors are compared. Then, a new model for series thyristors during the turn-off process is proposed, based on which the turn-off model of the converter valve is also established.

Control:

The paper ‘Directional derivative-based method for quasi-stationary voltage support analysis of single-infeed VSC-HVDC units’ by Perilla *et al*. presents an investigation of the impact of the quasi-stationary voltage support provided by a voltage-sourced converter (VSC) connected to a single point of a power system. Based on the directional derivative concept, an analytical method is developed to quantify the sensitivity of the AC bus voltage to VSC reactive power control modes. This paper shows that the proposed method can be applied to VSC units that are part of a VSC-HVDC system for both point-to-point and multi-terminal configurations.

Operation:

There are two papers in this topic. The paper ‘Availability assessment of voltage source converter HVDC grids using optimal power flow-based remedial actions’ by Rios, *et al*. proposes a methodology for assessing the availability of VSC-HVDC grids based on enumeration of $N-2$ contingency analysis. It also proposes a method to calculate remedial actions and propose a definition and computation method of reliability indices applied for HVDC grids. The authors propose computation of remedial actions based on optimal power flow to maintain power exchanges between HVDC and HVAC grids when a contingency occurs on the HVDC grid and converter stations or when HVDC lines are out of their operating limits. In the paper ‘Initialisation of a hybrid AC/DC power system for harmonic stability analysis using a power flow formulation’ by Lekić *et al*., a method to determine the operating point of the entire power system is studied. This operating point is needed for system linearisation for electromagnetic or harmonic stability analyses. To this end, each AC or DC power system component is modelled in the frequency domain (using Fourier transform) and is further adjusted to a simplified representation compatible with a power flow formulation. The paper also presents how VSC-HVDC-based systems can be analysed when the different VSC controls are applied. The result of the power flow solution is then used for initialisation of VSC units.

Protection:

This topic also has two papers. The paper ‘Controllable reactor based hybrid HVDC breaker’ by Heidary *et al.* presents the design procedure of a novel HVDC breaker based on a solid-state controllable reactor. This HVDC breaker can reduce the rate of rise and amplitude of fault current to less than the grid's nominal current in the breaking process. The main features of the proposed HVDC breaker are that (i) it does not pass the fault current; and (ii) none of the series HVDC equipment is influenced by the fault.

The paper ‘Detailed electro-dynamic model of an ultra-fast disconnector including the failure mode’ by Zaja *et al*. presents an ultra-fast disconnector (UFD) model suitable for DC grid studies for both normal and failure operation modes. The dynamic motion of contacts is analysed in detail and it is concluded that Thomson coil inductances including parasitic parameters plays an important role that needs to be modelled in detail, possibly using finite element modelling. The arc model of UFD is represented using a variable resistance in series with an ideal switch. The variable resistance is calculated analytically based on the instantaneous position of contacts and the circuit conditions.

Summary and conclusion

This Special Issue reports state-of-the-art research studies of interest to an audience with a background in HVDC and power electronics. We do hope that this Special Issue will provide a fruitful, educational, and inspiring reading opportunity.

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