Overvoltages experienced by DC cables within an HVDC transmission system in a rigid bipolar configuration

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ABSTRACT

Recent developments in MMC – HVDC schemes have resulted in increased power ratings and dc-side voltage levels which surpass 500 kV. Additionally, besides offshore applications, cable transmission is increasingly promoted also for onshore applications. To tackle challenges related to those developments, the rigid bipolar HVDC configuration is considered an attractive solution. First projects of this system type in the voltage range of 500 kV are already under construction.

This paper evaluates characteristic overvoltage transients in the rigid bipolar configuration. Selected EMT–simulation results highlight the different performance related to transient voltage stresses occurring in symmetrical monopolar schemes. Related findings help stakeholders to develop an understanding of the rigid bipolar configuration, and therefore contributes to ongoing discussions within the community.

KEYWORDS

EMT, MMC-HVDC, rigid bipolar configuration, XLPE cables

INTRODUCTION

The currently ongoing CIGRE Joint Working Group B4/B1/C4.73 investigates surge and extended over-voltage testing for HVDC cable systems. More specifically, the goal is to identify and characterize temporary overvoltage shapes experienced by the cable within modular multilevel converter (MMC) HVDC transmission systems in different configurations (monopolar, rigid bipolar). As an outcome of these studies, appropriate test levels and schemes are supposed to be suggested.

The main driver for these needs arose due to the fact, that today's standards and recommendations, e.g. [1, 2] leave general specification of cable stresses open for the customer-supplier negotiation process. Moreover, the switching impulse (SI) wave shape has been more and more challenged in recent discussions. Motivated by changes in converter topologies, impulses on longer timescales have been proposed to be relevant instead.

This paper investigates the overvoltage waveforms which might occur in a point-to-point scheme in rigid bipolar configuration. This configuration is one solution currently proposed for HVDC cable transmission systems in the voltage range of 500 kV. First projects utilizing this scheme configuration are already under construction.

Exemplary overvoltages occurring along the cable link are evaluated by means of electromagnetic transient (EMT) simulations, which consider different fault locations along the HVDC link. The aim of the case study is to provide exemplary cable overvoltages for the rigid bipolar configuration. Based on these findings, future work within the scope of the working group is intended to highlight substantial differences in rise or decay times, and to compare the results with existing peak amplitudes and rise times in today's HVDC cable test recommendations. Even though the obtained results do not represent a full-fledged parameter study, they contribute to ongoing discussions within the community.

HVDC SCHEME CONFIGURATIONS

Generally, both, the overvoltage level as well as the wave-shape experienced by the dc cable are strongly dependent on the HVDC scheme configuration and in particular the applied grounding concept. This section provides a brief overview of VSC – HVDC scheme configurations based on [3–5]. Basically, there are three HVDC scheme configurations: asymmetrical monopolar configuration, symmetrical monopolar configuration and bipolar configuration.

In the asymmetrical monopolar configuration, the scheme consists of two converters, where each converter is connected between a high voltage cable and ground, as shown in Figure 1. In asymmetrical schemes with ground return, both converter stations are equipped with elec-trodes to provide a current return path using the ground and/or the sea as a conductive medium. However, as continuous ground currents are restricted in most countries, other scheme arrangements make use of a dedicated return cable. Whereby dedicated return cables usually have reduced insulation requirements compared to the high voltage cable. In normal operation, the return cable isolation must be able to withstand the voltage drop along the conductor. Therefore, cable investment costs are reduced.

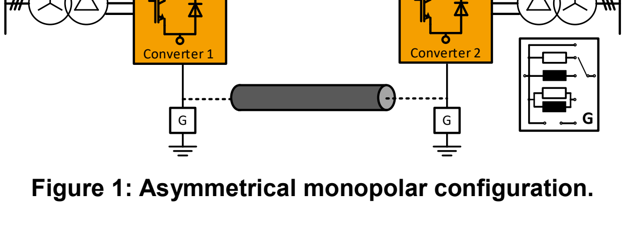

Figure 1: Asymmetrical monopolar configuration.