AC TO DC CONVERSION OF OVERHEAD LINES AND CABLE SYSTEMS – TRANSMISSION CAPACITY AND ENVIRONMENTAL ASPECTS

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Satisfying the ever-increasing demand for electric energy poses as an increasing challenge for the energy supply. Decentralized renewable energy sources are mostly used for the production of climate-friendly alternative energies. Consequently, the renewable energies need to be transported over long distances to the consumer centers. This presents an additional challenge for the transmission and distribution grid. To overcome these challenges, direct current (DC) transmission can be a solution. In addition to the described challenges, the construction of new overhead lines (OHL) and new cable system meets an increasing resistance in the general public. Therefore, the conversion of existing AC OHL and AC cable systems to DC operation provides an economic and time efficient solution.

With regard to the conversion of existing AC OHL to DC operation, already several projects are under way. At high voltage level (HV, ±380 kV) for example, the Ultranet project will help to provide a transmission corridor between wind power stations in the north and consumer centers in the south of Germany. Furthermore, CIGRE TB 583 provides guidelines regarding the conversion of AC OHLs to DC operation [1, 2].

The focus regarding the conversion of cable systems lies especially in the medium voltage (MV) DC transmission. This is related to the fact that DC cable systems with extruded insulation exhibit special phenomena compared to AC cable systems, which limit their suitability for HV applications significantly. In this regard, the accumulation of space charges, the field inversion and the thermal runaway need to be mentioned. Until now, a commercial 12/20 kV AC XLPE cable system including the corresponding AC accessories has already successfully passed a line commutated converter (LCC) prequalification (PQ) test and an LCC type test for a nominal DC voltage of U_{DC} = ±55 kV according to the specifications of IEC 62895 and CIGRE TB 852. Thus, the cable system is qualified for an LCC and voltage source converter (VSC) configuration. Furthermore, an innovative approach for a qualification procedure of MVAC cable systems with an extruded insulation has been presented recently [3, 4].

This contribution deals with the increase of transmission capacity obtainable from the conversion of existing AC OHL and AC cable systems to DC operation. Apart from technical challenges, environmental aspects and the associated remedial measures are discussed. The focus in this regard lies on the mitigation of audible noise emissions and the application of ecofriendly materials. Additionally, the qualification procedure for the conversion of extruded MVAC into MVDC cables will be highlighted.

Multiphysical FEM simulations have shown that in the case of the conversion and uprating of a 12/20 kV MVAC cable system with U_{DC} = ±55 kV into an MVDC cable system, the transmission capacity increases up to 5.7 times in comparison to the original MVAC cable system.

References

[1] O. Pischler, U. Schichler, S. Hedtke, P. Bleuler, C. M. Franck, “Corona Effects of Overhead Lines under Mixed AC/DC Stresses”, Chengdu 2019 Symposium, Chengdu, China, 2019

[2] CIGRE WG B2.41: 'Recommendations for Testing DC Extruded Cable Systems for Power Transmission at a Rated Voltage up to 500 kV', CIGRE TB 583, 2014

[3] P. Ratheiser, U. Schichler, “Qualification of MVAC XLPE Cables for DC Operation“, 22nd International Symposium on High Voltage Engineering (ISH), Xi’an, China, Report 118, 2021

[4] CIGRE WG B1.62: Recommendations for testing DC extruded cable systems for power transmission at a rated voltage up to and including 800 kV', CIGRE TB 852, 2021

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