MVDC DC-DC CONVERTER TECHNOLOGY

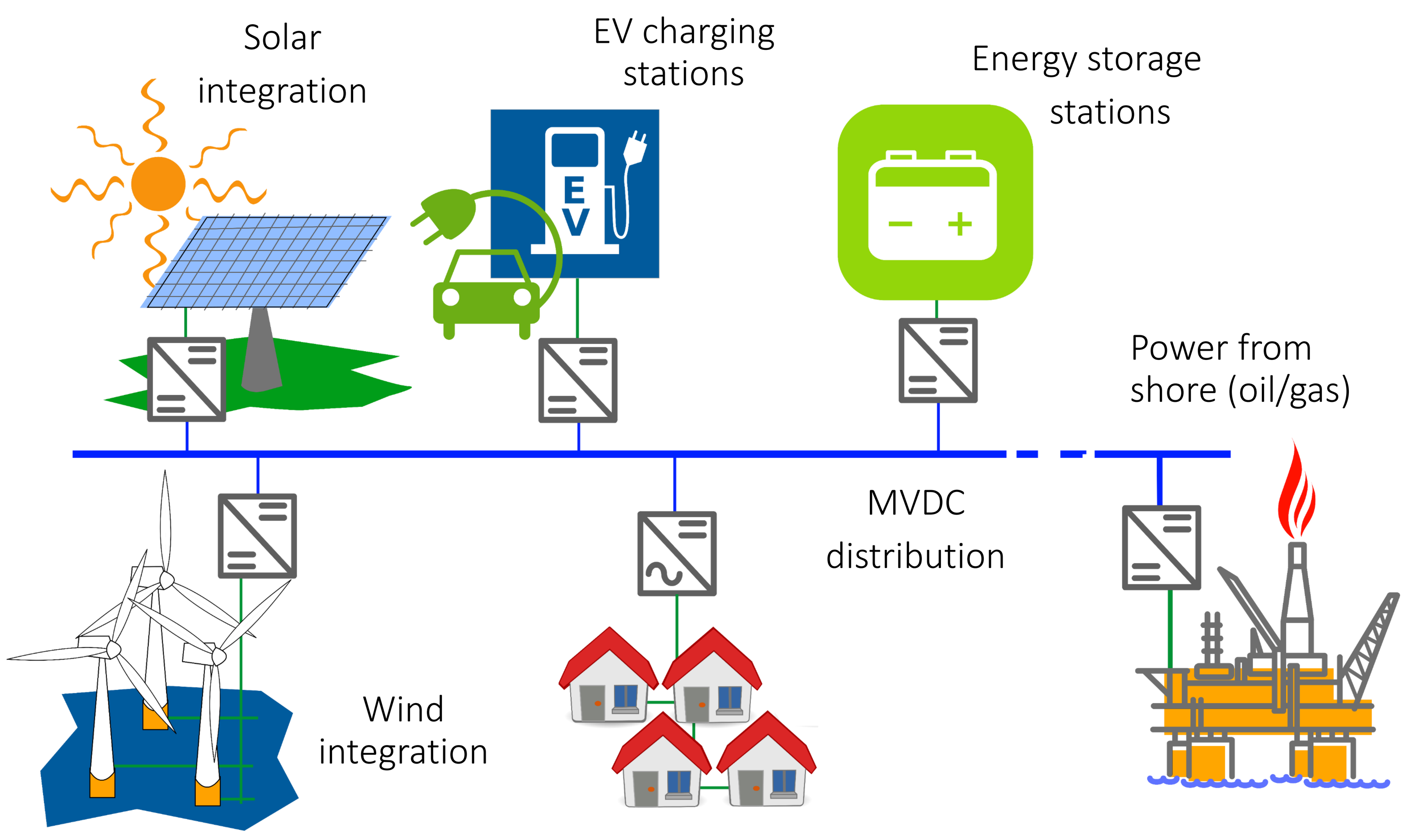
The building block of future MVDC grids

Abstract

This poster describes the DC-DC converter technology intended for Medium Voltage Direct Current grids. The benefits of the proposed technology are highlighted for the DC collector for offshore wind farms. The selected DC-DC converter topology enables the high stepping ratio and the latest generation of high voltage power semiconductor components is utilized to operate in the medium frequency range while optimizing the efficiency.

Background

The transmission of bulk power over very long distances is now reserved to high voltage direct current (HVDC) with voltages reaching 800 kV. Numerous research projects and some industrial projects target DC-DC power converters as a key component of the electrical networks. The DC-DC converters are often proposed for green energy and transportation applications such as photovoltaic, electric vehicles, wind power and railway electric traction. The offshore wind DC collector appears to be a cost effective solution as it allows to reduce the volume and weight on the offshore platforms and could be one of the first multi-terminal DC (MTDC) grids to be introduced. Such a wind farm architecture requires at least two types of DC-DC converters, both requiring a high stepping ratio: a MVDC DC-DC converter and a HVDC DC-DC converter. The recent technological improvements in wide bandgap semiconductors, such as the silicon carbide (SiC), has enabled the development of a competitive solution of the MVDC DC-DC converter.



SuperGrid Institute

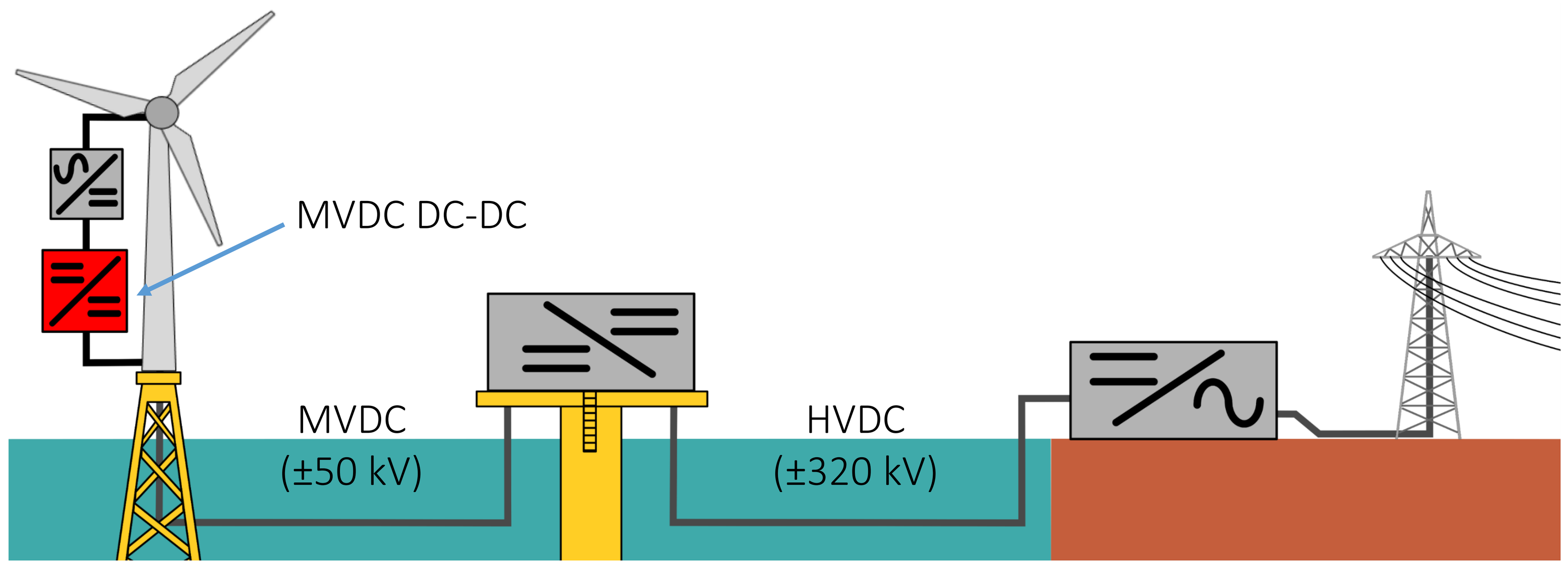
The Institute for Energy Transition (ITE) Supergrid is a collaborative research platform in the field of low-carbon energy, bringing together the expertise of industry and public research in the logic of public-private co-investment and close cooperation between all stakeholders of the sector.

The institute aims to develop technologies for the Supergrid that is the future electricity transmission network, using direct current and alternating current at very high voltages (in the order of one million volts), designed to transport large-scale energy from renewable sources remote from load centers, a significant portion of which are offshore, which will be in connection with flexible storage resources; to manage the intermittent nature of renewable energy; and also, to ensure the stability and security of the network.

Solution

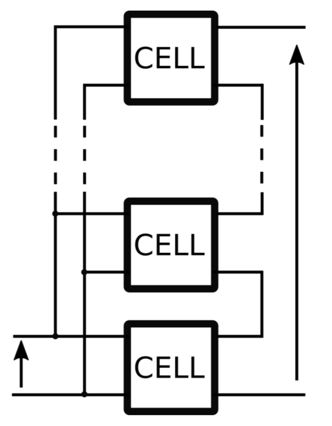
The proposed modular DC-DC converter covers a wide range of applications in future distribution DC grids operating at medium voltage levels but it has been optimised for an "all DC" offshore windfarm conversion chain. Assuming similar insulation constraints as for a 66 kV AC collector, an offshore DC collection grid of ±50 kV is envisaged. On the other hand a possible evolution of wind generators to 10 MW power and 4 kV DC output is used as the reference. The following benefits are expected:

- Eliminate the wind turbine transformer
- Eliminate the AC substation & HVAC transformer
- Optimise the MVDC cable: 2 cores, small section
- Avoid the resonance problems
- Reduce the overall cost

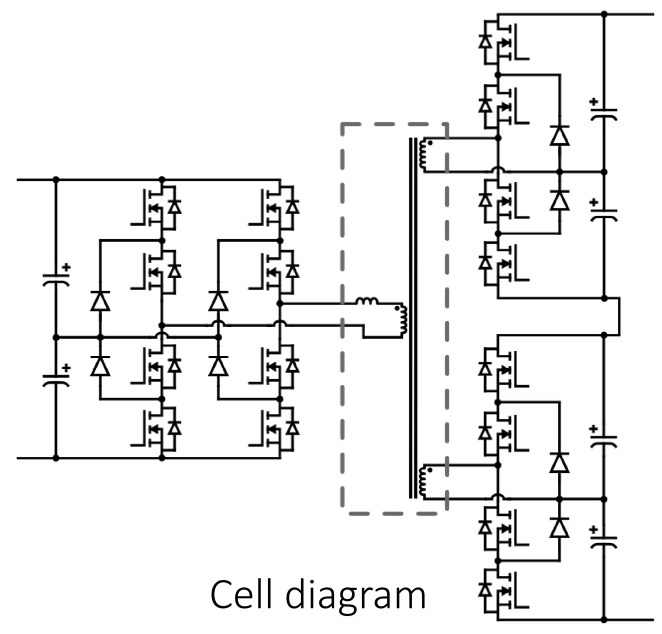


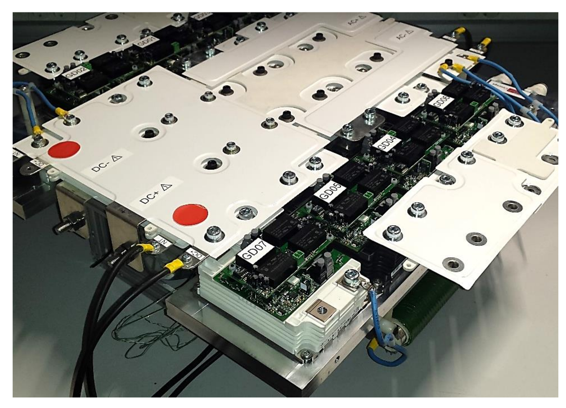
Details

The DC-DC converter is based on the cascaded multi-cell topology, an input-parallel output-series (IPOS) configuration, is selected to implement a 4 kV to 50 kV 5 MW DC-DC step-up converter. Whilst keeping the good performance of the conventional Dual Active Bridge (DAB) cell, the Triple Active Bridge (TAB) helps achieving the required transformation ratio of 12 with the minimum number of cells and overall number of components. A medium frequency operation at 20 kHz is selected for the AC link to reduce the size of both inductive and capacitive elements. A very high efficiency above 99% is expected. The cooling is assured by the deionized water flow.



Converter diagram


Cell diagram


Inverter prototype

Summary

The proposed MVDC DC-DC converter technology can be used in the wind range of applications. It has been optimised for the offshore wind DC collector grid with its small size and very high efficiency. The converter addresses many technological challenges including: high voltage silicon carbide (SiC) power semiconductor components, high power 100 kV DC insulated medium frequency transformer and innovative topology and controls. This DC-DC converter is an important milestone in the development of the DC grids.

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