Low Ripple Interline Power Flow Controller

Simple device adaptable to any requirement in terms of current and voltage reversibility

CONTEXT

HVDC transmission is a relevant solution in order to connect renewable energy sources (e.g. wind, solar) to load centres or to interconnect different areas over long distances. Until now, HVDC systems have usually been built as Point to Point (PtP) links. Nevertheless, in network development perspectives, meshed Multi-Terminal HVDC systems (MTDC) are a promising candidate for developing future transmission systems in regard to the high redundancy and reliability they offer for network operations. The DC network expansion in the future might be seen as a step-wise approach, starting with the construction of PtP and/or radial MTDC at the first step and following by the development of meshed MTDC which offers more flexibility.
However, the power flow distribution in a meshed HVDC network cannot be regulated independently as it is passively determined by the link resistances (lines and/or cables) and voltages of stations. Since the power flows are uncontrolled, some of the links may be overloaded while others may be used under their maximum capacity. This issue represents a special challenge in terms of the full network operation and requires a device for an effective control of power flow patterns in MTDC networks.

TECHNOLOGY DESCRIPTION

New concepts of Power Electronics (PE) converters known as Power Flow Controllers (PFC) or current flow controllers are proposed to tackle the management of power patterns' distribution in a meshed MTDC system by inserting a controlled voltage in the loop. This voltage is in the range of the voltage drops of links (some kV).
This PFC device is designed with passive components (capacitor and inductance) and Power Electronics Switches and do not require any connection to the ground. Any external source is mandatory since the energy of the links accumulated in the capacitors is balanced and shared thanks to the inductance. Thus, the PFC device is designed as a MV device. The energy needed for the converter operation (control boards, gate drivers...) can also be harvested from the capacitors since a voltage appears across these capacitors as soon as they are inserted into the grid. In addition, the presence of the inductance allows very smooth voltages and currents besides the limitation of the rate of rise of the current in DC fault operation. This low ripple PFC device has a proven ability to fit diverse power flow patterns for any network operation requirements. The proposed design of the PFC is also scalable and modular in respect to the network operation. The component count is low if the power flow patterns to be addressed are not numerous (for example inserted voltage and substations currents have not to change their signs) making this solution especially attractive for these application cases.

APPLICATION DOMAIN

Meshed Multi-Terminal HVDC grids
Parallel HVDC cables

ADVANTAGES

Enlarge the MTDC network operation.
Medium Voltage PFC device.
Low voltage and current ripples.
Scalable and modular designs

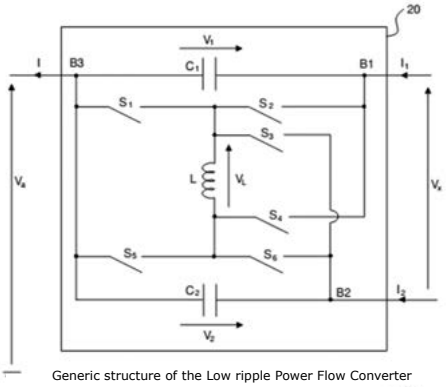
TRL SCALE

1 2 3 4 5 6 7 8 9

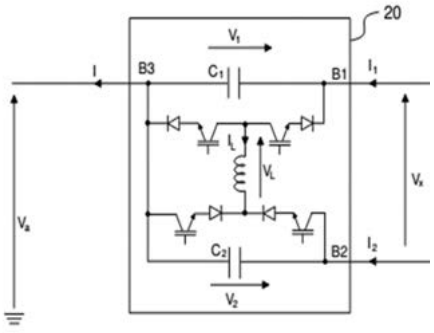
Concepts validated in EMT simulation

DELIVERABLES

Patent application WO2019016449 (A1)
Technical reports



Generic structure of the Low ripple Power Flow Converter



Example of PFC design with network requirements (I1/I2<0 and Vx<0)