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LV DC traction substation with connected bidirectional EV chargers and improved functionality

***Abstract**. Integration of bidirectional electric vehicle (EV) chargers into low voltage (LV) DC traction grids can potentially reduce chargers installation cost, as well as provide ancillary services for the DC grid, such as voltage stabilization, energy recuperation, reduced peak load and reactive power compensation. This paper presents connection scheme for bidirectional EV chargers integration into traction substations. Comparison of possible converter topologies that can be used in system is made. As a result, double DAB connection with one isolated DC link was chosen to be used in the system, due to DAB high efficiency of over 97%. Proposed solution can be beneficial for developing EVs and public electric transport, which uses LV DC grids, such as trams/trolleybuses/metro.*

Keywords: EV charger, bidirectional EV charging, smart charging, LV DC traction grid, DC/DC converters.

Considered connection scheme

Proposed connection to tram/trolleybus/metro substation in fig. 1, which additionally to APF(1,2) has converters DC/DC(1,2), allows integrate EV chargers into existing infrastructure as well as improve APF functionality. Thus, proposed scheme can perform next functions: braking energy recuperation; powering catenary during diode bridge failure; perform active power filter (APF), improving quality of electricity, consumed from AC grid; provide energy exchange between AC grid and DC-link, which simplifies connection of DC loads and sources to it; provide traction grid voltage stabilization and reactive power compensation.

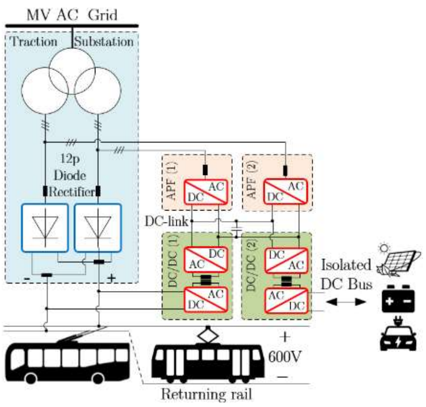

Fig.1. Possible EV charger isolated connection scheme.

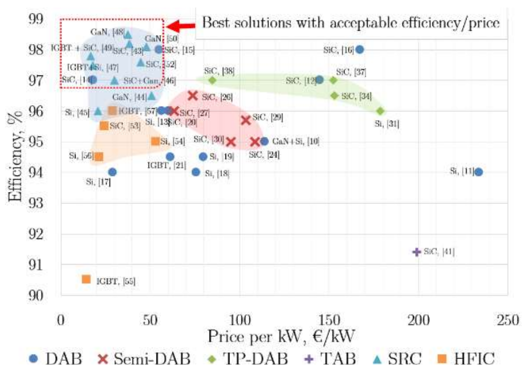

Fig. 2. Converters price per kW vs efficiency.

Converters topology selection

Important thing, that affect scheme applicability is the DC/DC converter topologies used in the scheme and their efficiency. Fig. 2 shows efficiency of the most promising converters that were found in the literature and can be used in system – Dual Active Bridge (DAB), Semi-DAB, Three-Phase DAB (TP-DAB), Tripple Active Bridge (TAB), Series Resonant Converter (SRC), High-Frequency Inverting Converter (HFIC). As can be seen, the most efficient topologies are some of SRC, DAB and TP-DAB converters, which can be explained by using active bridges both at the output and the input, as well as having ZVS and ZCS in a range of operation.

Conclusion

Proposed schematic solution can simplify integration of EV chargers into existing electrical infrastructure, which can be beneficial for electric transport development. Analysis of different converter topologies and their parameters showed that solution in fig. 1 with DAB converters allows providing necessary functions and galvanic isolation with relatively high efficiency of over 97%.

Acknowledgment

This research was funded by the EU Horizon 2020 FP Project: 955614— SMARTGYsum—H2020-MSCA-ITN-2020.

Literature

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