Abstract

This thesis project is made possible by the European project "Large demonstratIoN user CentrIc urban and long-range charging solutions to boosT an engaging deployment of Electric Vehicles in Europe" (INCIT-EV). The goal within the project is the creation of a charging hub for electric vehicles connected to the tram network of Turin. Specifically, the charging hub consists of 10 bidirectional chargers of 3.6 kW each and one fast charger of 150 kW. The thesis work focuses on the realization of the 10 bidirectional chargers. The connection to the tram network offers the undeniable advantage of eliminating an AC/DC conversion stage, but it presents significant challenges in the implementation of the DC/DC stage. This stage must not only regulate voltage and current to properly charge an EV but also have sufficient dynamics to reject a 600 Hz disturbance on the input voltage caused by the AC/DC conversion stage used for generating the DC bus of the tram network. In the analysis of the chargers, greater focus is given to the DC/DC conversion stage. After analyzing possible structures, the Dual Active Bridge topology was chosen. This structure is analyzed in detail, considering modulation techniques to utilize all degrees of freedom of this converter topology. The main electrical quantities of the structure necessary for the proposed design procedure are analytically derived. Then, an estimate of the losses in the main components of the DC/DC, namely the active elements, the transformer, and the inductor, is performed. These estimates are compared with the results obtained from the 3.6 kW DAB prototype. The thesis work then concentrates on the converter's control to propose a control scheme that allows the system to have high dynamic control bandwidth, capable of rejecting the 600 Hz disturbance at the input, and maintaining constant performance despite load and modulation technique variations. Finally, the prototype charger is presented, analyzing in detail the charging standard used, namely CCS2, describing how a bidirectional charging test was performed following a part of the standard that does not foresee bidirectional charging. The results of charging in the hub are reported, highlighting how it is possible to connect a charging hub for electric vehicles to the tram network.