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Title

Load Flow Analysis of Hybrid AC-DC Power Systems for the Application in Electrified Aircraft Propulsion

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Abstract

Due to the necessity for green-house gas emission reduction aviation needs new types of propulsion technologies. Here, electrification of aircraft propulsion is one possible approach and is in the focus of research in all aircraft classes [1]. The novel powertrain architectures introduce new challenges to the aircraft and propulsion system design. To assess these new topologies, the electric power flow and distribution has to be modelled and analysed in the sizing process of the powertrain. Although being rather new in aircraft propulsion, electric distribution networks are an extensively researched topic from land-based power networks or power grids. Such load flow calculation methodologies can generally be transferred to aircraft applications. Electric propulsion networks in aircraft though will likely comprise a mixture of alternating current (AC) and direct current (DC) due to different types of sources and loads. This requires, in contrast to a conventional load flow analysis, a suitable methodology to analyse the load flow in hybrid AC-DC networks. One approach for hybrid AC-DC load flow analyses was presented in [2], which was furthermore used for basic considerations of aircraft applications [3].

This paper proposes a modified implementation of the aforementioned hybrid AC-DC load flow methodology for aircraft powertrain application. The proposed methodology can be used for load flow analyses in electrified aircraft powertrain sizing. It therefore enables bidirectional power flow analysis for hybrid AC-DC networks and adds the possibility to change the voltage level between busses within the network. With the proposed methodology various electrified powertrain topologies can be set up and analysed regarding their load flow behaviour including active and reactive power flows, phase angles, voltage levels and losses. Furthermore, the proposed methodology can account for functional dependencies of system parameters, such as the efficiency of voltage source converters, on the power flow itself or on the voltage level.

The methodology is validated using commercial load flow software and test cases from literature. In following studies electric networks with different types of energy sources and numbers of loads, which correspond to typical topologies for electrified aircraft propulsion systems, are sized. The architectures are thereby analysed regarding their load flow distribution as well as resulting losses and voltage drop. In addition, studies for single points of failure in the system and their impact on the load flows and component loadings are performed and discussed.

References

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