Advanced Power Electronics for Aerospace Applications

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Auteurs: Jan Uhlig, S. Männl, M. Rottach, A. Engler
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Abstract

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Authors

Jan Uhlig

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Advanced Power Electronics for Aerospace Applications Jan Uhlig (1), S. Männl (1), M. Rottach (1), A. Engler (2) 1 : Liebherr-Aerospace Lindenberg GmbH, Pfänderstr. 50 – 52, 88161 Lindenberg / Allgäu, email: Jan.Uhlig@liebherr.com 2 : Liebherr-Elektronik GmbH, Peter-Dornier-Straße 11, 88131 Lindau

Abstract

Over the last decade a constant increase of aircraft electrification can be observed. Optimization of power electronic systems is seen as major challenge to make electric systems comparable to traditionally hydraulic systems. The optimization of the power electronic system components in weight, size, reliability and cost is an important task. Nevertheless, the application-specific global optimization on system level is the main factor of optimization. Optimization starting with the system design defines the boundaries for the components and has a large potential. Backed up with the long-time experience in both electromechanical and hydraulic actuation systems, Liebherr Aerospace will draw the roadmap towards optimized electrical systems and power electronics within this paper.

Introduction

The electrification of aircraft (MEA) results in a significant increase of power electronics in current and future aircraft. Power electronics are used in all potential replacements for traditionally hydraulic actuation in primary and secondary flight control, landing gear actuation or air conditioning applications. In the various applications, power electronics face different, but always challenging environment conditions. These environmental conditions in combination with the constant demand for lightweight, safe and robust systems put extraordinary challenges towards aircraft power electronics. In order to achieve competitive electronic systems on aircraft, an optimised system integration and an optimisation of the integrated electronics system is essential. Such a system integration approach allows the use of synergies and optimises overall power density, system weight as well as the reliability of the electric drive system. Special attention also has to be paid to the overall integration of power electronics into the electronic system in terms of packaging, thermal, EMI and maintenance aspects. In
this way, for example, peak power and thermal stress can be reduced significantly which improves the overall system reliability while increasing the power density. Electronic System Optimization As widely discussed in the aerospace industries, the optimization of electrical drive systems as a whole is a key enabler for efficient, light-weight and cost optimised power drive systems. Such an optimisation takes into account the interactions between the main drive components (electrical machine, power-electronics, signal-electronics, mechanical output,...). The following figure shows the key drivers for electronic system optimisation identified by Liebherr. Fig. 1: CREW: CostReliabilityEfficiencyWeight The global system design and optimisation uses the individual sub-component properties to determine a set of parameters for best system behaviour. This best system behaviour often does not coincide with sub-component optima. As an example, motor selection and design has major impact on the power electronic. Optimised motor selection can result in higher peak current demands and hence higher power electronics weight. This leads to a non-optimized overall system. Fig. 2: EMA Drive train optimization [1] As a result, an optimization approach on system level is necessary similar as described in [1]. Fig. 2 shows as an example the optimization tool and the main component interactions for a complete EMA drive train. With this system optimization approach fast design iterations are possible resulting in major system optimization. In general optimization based on physical aspects is proposed. The main physical parts of typical power applications are the mechanical design, the magnetic design, the electrical design (including power electronic, EMI, signal electronic and SW control strategies) and the thermal design of the system. Fig 3: Physical System Optimization As a result e.g. mechanical parameter variations have to be evaluated on thermal, magnetic and electrical effects and vice versa to optimize the system to the CREW parameters. In consequence, different areas of expertise have to be considered together in the system design and development. The main challenge is to allow fast system optimization iterations during the system definition phase while considering the positive and negative impact on components resulting from parameter variations. While only system level optimisation can provide satisfying results for future applications, it is required to constantly push the sub-components to their technological boundaries. Such an improvement on component level then needs to be evaluated on system level. The current and future advances in particular on a power electronics level will be described in the next paragraph. Key Technology Advances Based on the demands of the system optimization process, the electronic components have to be continuously improved. This section gives examples of Liebherr technology bricks development for each optimisation target. 1. Power Electronic Weight Optimization A main parameter in aerospace optimization is the weight optimisation: The optimization is driven by integration of components into housing, use of new materials or optimal usage of cooling capability. 2. Efficiency Optimization The efficiency of power electronics is mainly driven by the losses in the power devices. New technologies such as SiC-MOSFET are ready for application in aerospace application. Future technologies, like GaN components, are also being considered. The applicability of these new technologies has to be evaluated within the system optimisation process. Low power converter losses resulting from fast switching also results in higher stress on insulation systems and reduction of the power converter losses might increase the overall system weight. 3. Development Time and Cost Optimization Compared to hydraulic systems, electric system cost is not as attractive as hydraulic system. As described in [2], standardization is the main enabler for cost decrease and the closure of the small gap between electrical and hydraulic systems. The main drawback is the fact that standard modules are of increased complexity compared to special modules due to the need of additional flexibility to assure re-usability. The resulting main challenge is the definition of re-usable standard modules and interfaces on all levels to overcome the drawback of standardisation. Conclusions Based on the detailed knowledge in all areas of expertise, Liebherr is in a position to create optimized systems from system level down to individual component level for all aerospace drive system applications. References 1 ROTTACH Michael, Helicopter EMA System: Electrical Drive Optimisation and Test, Recent Advances in Aerospace Actuation Systems and Components, 2014, pp. 9 2 FERVEL Marc, MORE ELECTRICAL AIRCRAFT CONTROL, Recent Advances in Aerospace Actuation Systems and Components, 2014, pp. 29

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