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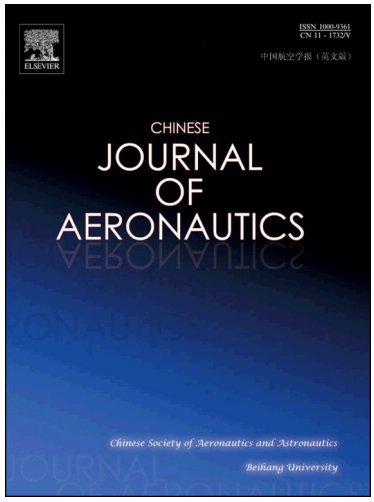

Review Article

Review on signal-by-wire and power-by-wire actuation for more electric aircraft

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REVIEW ARTICLE (INVITED)

Review on signal-by-wire and power-by-wire actuation for more electric aircraft

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Abstract

The huge and rapid progress in electric drives offers new opportunities to improve the performances of aircraft at all levels: fuel burn, environmental footprint, safety, integration and production, serviceability, and maintainability. Actuation for safety-critical applications like flight-controls, landing gears, and even engines is one of the major consumers of non-propulsive power. Conventional actuation with centralized hydraulic power generation and distribution and control of power by throttling has been well established for decades, but offers a limited potential of evolution. In this context, electric drives become more and more attractive to remove the natural drawbacks of conventional actuation and to offer new opportunities for improving performance. This paper takes the stock, at both the signal and power levels, of the evolution of actuation for safety-critical applications in aerospace. It focuses on the recent advances and the remaining challenges to be taken towards full electrical actuation for commercial and military aircraft, helicopters, and launchers. It logically starts by emphasizing the specificity of safety-critical actuation for aerospace. The following section addresses in details the evolution of aerospace actuation from mechanically-signaled and hydraulically-supplied to all electric, with special emphasis on research and development programs and on solutions entered into service. Finally, the last section reviews the challenges to be taken to generalize the use of all-electric actuators for future aircraft programs.

1. Introduction[1]

In recent years, aerospace actuation has made significant steps forward thanks to extensive introduction of the electrical technology at both signal and power levels. Despite scientific progresses and the industrial pressure to make aircraft safer, cheaper, and greener and to reduce time to market, efforts towards more electric then all electric aircraft are not always visible when one concentrates only on the solutions brought into service. This review intends to highlight recent advances and remaining challenges to be taken for enabling power-by-wire (PbW) to be extensively used for actuation in aerospace.

Following the systems engineering approach, any product development should follow a "top-down" approach starting first from the elicitation of needs and their transformation into requirements to define a proposed solution. In practice, this process is often reversed as a "bottom-up" process that consists of starting from (almost) mature technology for combining components to make equipment, subsystems, and then systems that offer new services to a customer. The first approach enables disruptive innovation but may ignore state-of-the-art technology and consequently may fail in putting a mature product into mass production. The second approach limits risks but only generates incremental innovation which brings low benefits when the employed technology has been well established for decades. However, this approach can take advantage of local step changes. A good example is found for hydraulic servo actuators (HSAs) that can be significantly improved by using new materials (e.g., carbon fiber reinforced housings[1]) and new manufacturing processes (e.g., additive manufacturing)[2-4] or by making them smart through integration of electronic boards and interfaces with digital networks. An intermediate or "middle-out" approach is effi-

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