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Title

Modeling and position control of electromechanical actuators for the tiltrotor conversion system of eVTOL aircraft

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Abstract

Electric aircraft, hydrogen aircraft, autonomous flight, sustainable aviation fuel, cargo drones and eVTOLs are six major technological trends that are disrupting the aviation industry[1], in which eVTOLs make a rapid progress in innovation for the development of "full electric aircraft". A significant proportion of eVTOL aircraft is designed to provide urban air mobility (UAM) solutions for release traffic congestion and air pollution[2]. Therefore, eVTOLs development landscape is highly active in USA, Europe and China, and novel types of concepts become increasingly more energy efficient and higher reliability level.

Recently, one of the most popular research designs for eVTOLs is the tiltrotor type, in which a pair of proprotors is tilted in a range from about 90° to 0, so that the thrust direction changes from upward for vertical takeoff to forward in cruise and back to upward for vertical landing[3]. To flexibly convert tiltrotor eVTOLs between vertical helicopter mode and horizontal airplane mode, a tiltrotor conversion actuation system is essential and crucial. The primary safety issue is to reduce the probability of "loss of control" of the rotor in the transition mode. Therefore, the conversion system typically consists of two tiltrotor or pylon conversion actuators and a mechanical cross shaft connecting the actuators to ensure position synchronization of the motion. Advanced eVTOLs have new features that lead to lightweight and low-cost construction, the mechanical flex-shaft could be removed, and position synchronization of tiltrotor could be achieved using electrically signaled synchronization loops of distributed electrical actuation system[4].

This communication introduces the design configuration of the electrical actuation conversion system for the quadrotor eVTOL aircraft. The rotors are pitch controlled by the extension and retraction of independent electromechanical actuators (EMAs), whose positions should be synchronized at all times. However, due to the different nature dynamics and air loads, the independent EMAs tend to have different displacement, so position synchronization amounts to ensuring the uniform movement of multiple EMAs and preventing actuator failure. At this point, a virtual prototype of the conversion actuation system is first proposed to evaluate the structural strength performance using the Ansys/Workbench platform. Then, a model-based approach for the position synchronization control of EMAs is proposed, which takes into account the physical effects to make the simulation as realistic as possible and adapt it to the implementation for performing real tests.

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