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RESEARCH ON NOVEL INTEGRATED RUDDER ACTUATION SYSTEM FOR SPACECRAFT REENTRY AERODYNAMIC CONTROL BASED ON DOUBLE DIGITAL CLOSED CHANNELS OF POWER MANAGEMENT AND LOAD DAMPING

Abstract

Actuation systems in aerospace applications are used to meet the spacecrafts control requirements while minimizing size, weight, and cost. The characteristics of high power-to-weight ratio and precise control make Electrohydraulic Actuation System (EAS) an ideal choice for use in flight control in despite of its disadvantages of low efficiency, leakage, contamination and high maintenance. According to the difference of hydraulic power unit the EAS consists of gas driving or motor driving unit. The purpose of this paper is to develop a novel rudder actuation system which comprises a digital controller, a hydraulic energy source driven by brushless DC (BLDC) motor, one or more hydraulic actuators and a thermobattery. The double digital closed channels, including improved dynamic pressure feedback (DPF) from the new kind of silicon piezoresistive transducer and the real time regulation of hydraulic pump velocity, are used to improve EAS efficiency and damp system resonance caused by low installation stiffness from excessive structural compliance. Firstly, the basic concept of rudder EAS and their functions are introduced. Then, the control scheme for EAS, utilizing hydraulic pressure closed loop and position closed loop based on digital signal processing (DSP), is described. The continuous control of rotational speed of BLDC motor is used to improve the efficiency of power transmission and keep the hydraulic pressure constant under any rudder deflection command according to the preset control law between hydraulic pressure and motor velocity. Digital closed loop is built for the control of actuator position with digital load damping in order to achieve the required frequency response. Load damping is implemented by digital DPF in which high-passed of load signal of differential pressure transducers provides the necessary damping and flexibility and efficiency for control of frequency response. Moreover, the development of digital EAS control model, including electrohydraulic servo valve, piston and load dynamics, is expatiated on. Finally, the performances of computational model of such an EAS based on modeling in computational environment of AMESim are analyzed and the responses of the model are compared with results of conventional system. In conclusion, above EAS with power management technology of motor speed regulation can be well-designed as a well-behaved system being free of resonance and high energy efficiency for rudder surface control of spacecraft reentry.