SPACE SYSTEMS SYMPOSIUM (D1)
Interactive Presentations (IP)

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ADAPTIVE FAULT TOLERANT SERVO SCHEME FOR LAUNCH VEHICLE CONTROL ACTUATION SYSTEM

Abstract

The new generation satellite launch vehicles have complex mission requirements and involve high development and realization cost. These missions call for highly reliable onboard systems. Efficient Fault Detection and Isolation scheme along with necessary hardware redundancy is the best approach for reliable and fault tolerant onboard systems. The fault detection and isolation scheme adopted for the Flex Nozzle Control system of a new launch vehicle is discussed in this paper. A simple innovative way of fault detection scheme with adaptive threshold has been adopted in this design. The launch vehicle uses electro-hydraulic servo actuators for attitude control. These actuators make use of a combination of Direct Drive Valve driven by Linear Force Motor and Hydraulic Amplifier Valve for flow control. A five layer analog feedback controller is required for the optimal performance of the servo system. As the failure of any components in the servo actuation system is critical, dual redundancy is provided for control electronics and sensors. Fault tolerance in dynamic systems is generally achieved through the use of hardware redundancy or through analytical redundancy, which have its own merits and demerits. The new scheme adopted in the Flex Nozzle Control system is a blend of the above two fault detection and isolation concepts. A second order model with rate limiting is used to mimic the system behavior in the frequency range of interest. Position output of the model is used as the reference and it is compared with the actuator position sensor output for fault detection. End to end parallel hardware consisting of, control electronics, compensator, motor coil and sensors, is used as the redundant chain for reconfiguration through a controlled switch. A simple innovative way of fault detection scheme with varying threshold concept is developed for timely detection of system faults. The requirements of complicated algorithms and fast processors are avoided by realizing the model and the fault detection algorithm through analog circuits. This novel scheme has been incorporated in the above said actuation system and the adequacy has been established through various levels of practical system testing and the fault detection system parameters were tuned for optimal performance. The impact of transient during switch over from prime to redundant chain on vehicle performance has been studied by introducing various failures during actuator in loop simulation tests. The strength of the scheme against false alarm for flight conditions has proven in the maiden flight.