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A DSP PROCESSOR BASED ON-BOARD SYSTEM DESIGN FOR VIBRATION SENOR DATA ACQUISITION AND PLAYBACK IN GSAT-4 SPACECRAFT.

Abstract

Stringent on-orbit structural performance specifications for advanced communications missions require inclusion of the effect of on-orbit structural dynamic behavior of spacecraft in the design and subsequent simulation to verify the performance of payloads. The source of vibratory disturbance on-board the spacecraft are mainly the rotating elements such as momentum wheel, reaction wheels, gyros and solar array drives. In addition, elements like antenna pointing mechanisms, payload slewing and rotation mechanisms, mission related events such as appendage deployment, LAM firing, thruster firing during station keeping operations, as well as thermo-elastic shocks experienced by spacecraft while entering and coming out of eclipse results in vibratory disturbances in the spacecraft. Understanding the structural dynamic behavior of the spacecraft under these vibratory disturbances is extremely important in future structural design of spacecraft as well as for fine pointing control of the satellite. It is also necessary to understand the interaction of flexible appendages, wheels with other spacecraft elements and validate/update the mathematical models used for the analysis of on-orbit and launch phase performance based on the measurements and subsequent response analysis along with subsystem weight and mass optimization with improved merging of safety and reliability. Furthermore, from the response data obtained during on-orbit measurements, studies are planned to estimate micro gravity / jitter /agility data, in the presence of actuator operations (wheels, thruster firing, and steering mechanisms for ka-band antenna), estimate the shock moment induced during the deployment of the solar array, experimental modal analysis of spacecraft with deployed appendages with excitation provided by thruster firing (transient excitation for the spacecraft), monitor the low frequency loads induced on spacecraft during launch phase, and dynamic interaction studies of structure, sensors (earth sensors, etc) and actuators (momentum wheels, thruster firing, etc).

The On-Board Structural Dynamic Experiments (OSDE) subsystem of GSAT-4 has been proposed and designed with the above motioned objectives. This experiment consists of a number of transducers (accelerometers) mounted at various locations on the spacecraft so that suitable excitation of the different parts of the structure is sensed by the accelerometers. The signals are conditioned and stored in the on-board solid-state memory. These are then transmitted to the ground through telemetry at suitable time during the mission operation. The whole system is divided into three cards specifically, the analog signal conditioning card, DSP processor card, and the dc-dc card. While, the analog signal-conditioning card suitably amplifies and filters the signal from the accelerometers for acquisition by the DSP processor card, the dc-dc card provided suitable power supply to all the components and active element in these cards. The functionalities of the system are embedded in the system software and hardware such that it performs as a hard real-time system. The OSDE subsystem software that uses a round robin scheduling scheme, performs the major function of sensor data acquisition, 1553B communication with Bus Controller system, telecommand processing, telemetry of the health parameters, playback of the experimental and analyzed data to ground stations at high speed, and on-board analysis of the experimental data to study the structures with time-varying dynamics. The analysis software includes spectral estimation, modal parameter estimation, and shock analysis. The system is event and command driven and is configurable using ground commands. It has several modes of operation that are commanded based on the mission operations and objectives. In the primary modes of the system, vibration data from different parts of the spacecraft is acquired and estimation of the vibration frequencies can be calculated. The information is systematically stored and transmitted to the ground for exhaustive analysis to optimize the structural design. The complete software for this subsystem is developed using Unified Modeling Language (UML) and implemented using a combination of assembly and C to meet the real-time constraints. It is realized using the radiation-hardened version of the Analog Devices ADSP-21020 (TSC-21020) processor. This paper gives a detail design of the above system which is being planned to fly in GSAT-4 spacecraft.