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HIGH ACCURACY POINTING AND STABLE CONTROL SYSTEM FOR INDIAN SOLAR MISSION (ADITYA-L1)

Abstract

Aditya-L1 is the first Indian solar observatory mission meant for uninterrupted study of solar phenomena from Sun-Earth Lagrangian point(L1) which is 1.5 million Kms from Earth.
It carries seven payloads out of which Visible Emission Line Coronagraph(VELC) is the main payload to detect the development and dynamics of Coronal Mass Ejections(CME's) and perform the spectroscopic observations. The coronagraph is designed to view the solar corona from 1.05 Rsun till 3Rsun (Rsun-Sun Radius). An offset of 0.05Rsun will bring in the solar disk onto the payload mirror which can damage the payload. This calls for stringent spacecraft pointing and stability requirements of 45 arc-s and 5x10-5 deg/s respectively.
The spacecraft is configured with various actuators i.e. Magnetically Suspended Reaction Wheels(MSRW), thrusters, Liquid Engine and sensors such as Star Sensors(SS), High Accuracy Active Pixel Sun Sensors(HAPSS), Inertial Referencing and Accelerometer Package(IRAP) and Four-Pi Sun sensors for different mission phases such as Earth bound, heliocentric, L1 centric and orbit raising operations. Selection of actuators and accuracy requirements of the sensors were worked out to meet the mission specifications. MSRW was selected instead of ball bearing reaction wheels in view of minimizing bearing friction and stiction near zero speed. Also, gyro has two modes of operations for achieving higher accuracy in L1 phase and higher range selection for maneuver operations.
HAPSS is mounted to get most accurate pointing about axes normal to payload boresight, which ensures boresight direction meets the observation requirements. An innovative design was carried out towards knowledge enhancement for controller using best available on-board attitude measurements in hybrid mode. Here the attitude information from HAPSS and SS is used to update the gyro referenced inertial quaternion at their respective sampling instant. The resultant accurate information is used for control during L1 centric phase to meet the stringent pointing and stability requirements.
Autonomy features such as desaturation of wheels, gyro drift rate compensation (DRC) update using Combined Kalman Filter(CKF) and autonomous orbit maneuvers and corrections were designed and implemented. To maximize payload operation in L1 orbit, wheel desaturation is planned along with orbit maintenance operations. This was achieved by detailed Solar Radiation Pressure(SRP) studies, proper

reaction wheel sizing and biasing of wheel speeds. Torque compensation scheme for disturbance caused by rotating elements in payload such as SUIT Filter Wheels was also designed for achieving a stable platform.
Keywords: Aditya-L1, solar mission, Lagrangian point, pointing, stability, sensors, actuators, momentum desaturation, SRP