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Author: Mr. ASHOK KUMAR K
U R RAO SATELLITE CENTRE (URSC), India, kashok@ursc.gov.in

Dr. SIVA MOHAN SUNDARA
U R RAO SATELLITE CENTRE (URSC), India, mssiva@ursc.gov.in
Mr. Harish Joglekar
ISRO Satellite Centre (ISAC), India, harish@isac.gov.in
Mr. Chiranjib Guha Majumder
Indian Space Research Organization (ISRO), India, chiran@ursc.gov.in
Dr. N K Philip
Indian Space Research Organization (ISRO), India, philip@ursc.gov.in

CMG BASED STEERING FOR ENHANCING AGILITY OF HIGH THROUGHPUT SATELLITES

Abstract

With advances in satellite imaging, the need for high resolution imaging is increasing. Both high resolution and number of spots collecting capability is the main requirement for high throughput satellites. Reaction wheels are used to get better pointing and stability, but the power constraints impose maximum torque possible with reaction wheels and hence spacecraft agility.To meet the agility and pointing requirements of Agile Spacecraft, new Attitude Control System (ACS) approach is presented here, in which Single Gimbal Control Moment Gyro (SGCMG) used as a main Actuator. The CMG cluster configuration comprises of 4 SGCMGs with gimbal axes normal to mounting plane. Each CMG provides angular momentum and torque capacities in the plane orthogonal to the gimbal axes. The SGCMGs can operate in two modes viz.,Gimbal Rate (or Gimbal) Mode or Spin Rate (or Wheel) Mode. In the gimbal mode of operation of CMG, the gimbal wheel is made to spin at constant speed and the control demand is provided in terms of Gimbal rates which is computed in OBC, based on control requirement (as a function of attitude error and attitude rates) and realized gimbal position by previous cycle actuation. In theSpin Rate Mode of CMG, the wheels are operated in Torque Control mode and wheel speeds are varied in proportion to Torque Control which is again a function of attitude error and attitude rates. In the Wheel mode of operation of the CMG, the respective CMG gimbals are held to pre-set or desired gimbal angles using gimbal holding torque. In this way, the actuator switching from Gimbal mode to Wheel Mode and vice versa take place through Actuator switching method which is implemented based on torque demand on the respective actuator modes.

To handle inherent CMG singularities, the new CMG guidance algorithm has been designed and implemented in On Board Computer (OBC) which ensures singularity avoidance of the CMG clusters and there by achieving higher agility within CMG momentum envelope.This algorithm, converts ACS torque commands into gimbals Rate commands. The Rate to Rate Maneuver profiles for Landmark tracking were used here to demonstrate the CMG Steering algorithm. Also, Re-orientation algorithm for moving the CMG gimbals to Preferred orientation for the next Imaging Session was implemented and demonstrated in real-time. The performance of the CMG based ACS during Real time Maneuver and Imaging Operation has been presented for various cases like Single strip, Multi strip Imaging operations with various Eigen axis Torque. In all the operations, the Forward and Reverse Maneuver performed in Gimbal Mode of operation. The Control Error and Stability (Residual Rates) are well within specifications i.e Control Error is $<$ 5e-04 deg and Residual Rates $<$ 5e-05 deg/sec. The maximum Gimbal Angle variations

during Maneuver: 120 deg over Homing position and the wheel Speed variations during target tracking is 50 RPM. The Performance of CMG based ACS system is meeting the stringent pointing and stability requirements. Hence the control realization algorithm designed in this work has been demonstrated on-orbit for improving the throughputs of agile satellites for getting better resolution.