Paper ID: 44661
student

46th STUDENT CONFERENCE (E2)
Student Conference - Part 1 (1)

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GROUND BASED ANGULAR RATE RECONSTRUCTION WITH INTERMITTENT MAGNETOMETER DATA FROM PHOENIX CUBESAT

Abstract

PHOENIX is one of 2U CubeSat in the QB50 project. The CubeSat was designed, assembled, integrated, tested, and operated by National Cheng Kung University, Taiwan. After the launch in May 2017, it was found that the satellite is subject to a high tumbling behavior during the initial commissioning phase. This behavior was later found to be attributed to the improper execution of the flight control software, which essentially destabilize the satellite. The sensor data that are available include the three-axis magnetometer data and one-axis gyro data along the pitch direction. As the sensor data are recorded as a low rate intermittently, it becomes extremely challenging to stabilize the satellite as the available information is limited. This paper discusses an approach to resolve the attitude determination and control issue based on partial and intermittent data. With the objective of maintaining 3-axis alignment with ram direction pointing for scientific payload operation, the attitude determination and control subsystem of the PHOENIX employs a set of attitude control laws and estimators. The determination of the control and estimation parameters can be conducted more effectively based on ground based simulation even though the satellite is already in orbit. Indeed, the triggering of the high tumbling effect of the PHOENIX is confirmed by using the simulation. To tackle the tumbling issue, several methods are developed. The methods are simulated on ground and then tested in orbit. This paper presents the approach to reconstruct the attitude behavior based on ground simulation with partial/intermittent flight data. More precisely, this paper presents an estimation method for 3-axis angular rate with intermittent magnetometer data from PHOENIX based on extended Kalman filter (EKF). Utilization of EKF is a well-known technique, and the state estimation is a combination of state propagation from dynamic equation and state correction with observation update. To deal with low sampling rate and intermittent measurement, it is realized that the error due to state propagation can be significant as the dynamic system is essentially nonlinear. To this end, a novel method is proposed to deal with long period of measurement update. The Y-axis gyro telemetry data are then compared with the estimation results based on dynamic model and magnetometer data. With the proposed angular rate reconstruction approach, parameters like moment of inertia and state noise covariance can also be characterized. This, in turn, leads to the better performance of attitude control laws and estimators on-board.