46th STUDENT CONFERENCE (E2)
Educational Pico and Nano Satellites (4)

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# ANALYSIS OF TUMBLING MOTIONS BASED ON LIMITED TELEMETRY DATA AND RADIO SIGNALS

**Abstract**

PHOENIX is a 2U CubeSat that is developed by the National Cheng Kung University as a part of the QB50 project. The PHOENIX was deployed from ISS in May, 2017 and has been successfully communicated with the ground station in Taiwan. In the early orbit phase (EOP), the PHOENIX was subject to a significant tumbling behavior to the extent that the rate sensor is saturated. The paper addresses the efforts in recovering the PHOENIX CubeSat from tumbling by the analysis of limited telemetry data and radio signal strength. A sufficient amount of reliable telemetry data is needed to analyze the attitude behavior of the satellite once the satellite is subject to high dynamics. The EOP data of the PHOENIX are found to be intermittent, un-calibrated, and subject to saturation, making the analysis and control very challenging. The PHOENIX CubeSat is equipped with a three-axis magnetometer and one-axis rate gyro for attitude sensing. As the rate gyro was found to be saturated, the magnetometer data are the only useful data for rate and attitude determination. The effort in the determination of the rotation axis and rotation rate is augmented by analyzing the radio signal waveform. To this end, a software receiver is used to record the intermediate frequency samples of the received signals. Through the correction of the antenna gain and a series of signal processing such as filtering, windowing, and spectral analysis, attitude-related information are obtained and used to confirm the analysis results. Consequently, attitude control actions were then taken to detumble the satellite and the PHOENIX was eventually stabilized. In the paper, the analysis approach and results will be discussed. It is believed that the analysis approach will be applicable to many low-cost CubeSat missions.