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EXPERIMENTAL VALIDATION OF AGILE ATTITUDE CONTROL WITH SINC FUNCTION-BASED PROFILER FOR REDUCING RESIDUAL VIBRATIONS

Abstract

This paper presents an experimental validation of a new algorithm for agile tracking control of flexible spacecraft with sinc function-based command shaping where the spacecraft attitude is controlled along a sequentially commanded trajectory and the residual vibration after the move can be significantly reduced. Sinc function is known as an extra-insensitive function which has no frequency response above a certain threshold frequency. The conventional attitude control algorithms for flexible spacecraft are not effective for multi-mode system with unknown flexible modes, although actual flexible spacecraft usually has such unknown high-order flexible modes. However, the proposed sinc function-based feedforward algorithm for flexible spacecraft attitude maneuvers can reduce residual vibrations after the maneuvers to a smaller level compared to conventional methods in case that unknown high-order flexible modes exist in the spacecraft structures. The experimental validation is performed by hardware-in-the-loop (HIL) test configuration with newly developed real-time onboard computer to evaluate the feasibility of processing load by the proposed algorithms for real-time processing. Because all the proposed algorithms do not contain any iteration algorithm, the proposed algorithms can be implemented in actual satellites with feasible processing load. In this paper, numerical simulations and experimental validation are made by using the sinc function-based tracking control where the spacecraft is controlled along a sequentially determined arbitrary trajectory. The convolution of sinc function-based profile $f(t)$ and a sequentially determined arbitrary trajectory $g(t)$ is given as

$$h(t) = \int_{-\infty}^{\infty} f(\tau)g(t-\tau)d\tau$$

where $f(t)$ is previously determined function consisting of sinc function and $g(t)$ is an arbitrary trajectory for spacecraft target attitude profile. If $f(t)$ is defined in a finite time domain, $h(t)$ can be calculated in concurrence with the sequentially determined profile $g(t)$, then the residual vibration after the move can be minimized where the spacecraft attitude is controlled along the sequentially commanded track. Numerical simulations and experimental results are presented to demonstrate the effectiveness of the

proposed sinc function-based tracking control when applied to simplified flexible spacecraft model where two-mode systems with an unknown high-order mode have been used as simplified model of flexible spacecraft. The assumed two-mode system represents the most simplified multi-mode system with unknown high-order mode, so the similar results can be expected for systems equipped with more complicated flexible structures.