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ON-OFF ATTITUDE CONTROL USING PULSE-WIDTH PULSE-FREQUENCY MODULATED INPUT SHAPER

Xing-Yuan Xu and Yuan-Li Cai

Department of Automatic Control
Xi'an Jiao Tong University, Xi'an 710079, P. R. China

Abstract. Kinetic kill vehicle (KKV) is actuated by on-off thrusters to adjust its attitude, how to modulate continuous control commands to on-off or pulse signals to meet the requirements of the thrusters is a challenging task. Pulse-width pulse-frequency (PWPF) modulation is an effective method that provides pseudolinear operation for on-off thrusters. In this work, a new thruster configuration of the KKV and its mathematical model is proposed, good guidelines for the PWPF parameters tuning task is presented, the linear quadratic regulator (LQR) technique in combination with PWPF is used to design the optimal attitude controller. The validity of the proposed methods is demonstrated through the three-axis nonlinear numerical simulations of the KKV of this work.

Keywords. Attitude control; KKV; LQR; Optimal control; PWPF.

1 Introduction

The interception and destruction of a hostile reentry vehicle was once thought to demand the detonation of a bomb. This scheme had several drawbacks, notably, the kill mechanism might not be benign to the assets it was supposed to protect. Moreover, even a small bomb weapon, being heavy, needed a large and costly missile for its delivery. With the development of small-size propulsion mechanisms, reliable and accurate sensors and guidance systems, and rapid servo-mechanism techniques, the kinetic kill vehicle (KKV) is now becoming both technically and economically feasible. A KKV is steered to directly impact a rapid moving target, which makes a low-cost defense system more promising [1-3]. Each KKV requires six to eight thrusters to maneuver its pitching angle, yawing angle, and rolling angle. The thruster's time delay from command-to-fire to full thrust must be in milliseconds, and the thrust must substantially exceed vehicle weight. A procedure for finding the optimal thruster configuration with desired control effectiveness was proposed by reference [4].

In this work, pulse-width pulse-frequency (PWPF) modulator is considered as a feasible option for the reaction thruster attitude control system (RTACS). The PWPF modulator is choosed to transforms continuous control commands to on-off signals due to its advantages over other types of pulse modulators, for example, the bang-bang controller consumes excessive