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# PERFORMANCE ANALYSIS OF AN ATTITUDE CONTROL SYSTEM FOR SMALL SATELLITES

**Abstract**

In the last decades, there has been an incremental trend in designing small satellites for Earth Observation and other space applications. Depending on the type of sensors adopted, Attitude Determination and Control (ADC) requirements may be very different, and the selected control algorithms may implement different solutions depending on computational performance and sensors accuracy. In detail, pointing requirements may be very restrictive and the ADC System (ADCS) shall be compliant with these requirements, ensuring their satisfaction through the implementation of robust control algorithms and design of a proper actuation system. In designing the complete ADCS, two control laws are considered: (i) a reconfigurable PID controller and (ii) a Sliding Mode Controller (SMC). The objective of this paper is the design of a robust flight software, in which the key features are (i) suitably designed control laws to guarantee the robustness to uncertainties and (ii) detailed model of the external disturbances, focusing on Low Earth Orbit (LEO) missions. The design of the reconfigurable PID controller includes both failure and de-saturation modes. For the evaluation of the stability and of the robustness performance, phase and gain margins are computed. In designing the SMC methodology both first and second order SMCs are considered and are designed to manage failure and de-saturation of the attitude control actuators, as for the proposed PID controller. The SMC is discontinuous and depends on suitably designed switching functions and it must guarantee that the system trajectories reach and maintain a motion on the desired sliding manifold. To accomplish our mission task and to design a robust flight software, SMC is able to provide global stability and ensure insensitivity and robustness to system uncertainties and external disturbances under rather mild assumptions. Finally, the second order SMC is introduced with the aim of reaching the sliding manifold in finite time by means of continuous control, which is useful for the attitude control of a spacecraft provided by continuous actuators (reaction wheels), while the first order SCM is more suitable for discrete actuators (non-throttleable reaction control thrusters). Extensive simulations are performed to prove the effectiveness of the proposed ADCS in a LEO mission scenario, including uncertainties of the spacecraft configuration, measurement and actuation errors. Moreover, a detailed model of external disturbances is included, since this controller is proposed for LEO missions. Performance of both controllers are evaluated, including alternative methods for phase/gain margins, to guarantee the robustness of the control system.