47th STUDENT CONFERENCE (E2)
Student Team Competition (3-GTS.4)

Author: Mr. Ajinkya Phanse
College Of Engineering , Pune, India, phanseaa15.elec@coep.ac.in

Mr. Chirag Joshi
College of Engineering, Pune, India, chiragbjoshi2@gmail.com
Mr. Onkar Murkewar
College of Engineering, Pune, India, onkarmurkewar@gmail.com
Mr. Atharva Karaguppi
College Of Engineering , Pune, India, atharva011998@gmail.com
Mr. Shubham Thorat
College of Engineering, Pune, India, shubhartho13@gmail.com
Mr. Madhur Nalawade
College of Engineering, Pune, India, madhurnalawade@gmail.com
Mr. Onkar Bhakare
College of Engineering, Pune, India, onkargnbhakare@gmail.com
Mr. Aman Gupta
College of Engineering Pune, India, guptaa17.elec@coep.ac.in
Ms. Shariva Dhekane
College of Engineering Pune, India, dhekanesv17.extc@coep.ac.in
Ms. Manali Durgule
College of Engineering Pune, India, durgulems17.instru@coep.ac.in
Mr. Akshay Deodhar
College of Engineering, Pune, India, akshayrdeodhar@gmail.com

DESIGN AND COMPARATIVE ANALYSIS OF NOVEL TECHNIQUES FOR REACTION WHEEL TORQUE CONTROL IN ACCORDANCE WITH ATTITUDE CONTROL LAW OF SATELLITE

Abstract

This paper presents the design of the attitude control system of a nano-satellite employing two novel topologies for achieving precise control of torque from Reaction Wheel(RW). COEPSAT-2 is a student satellite mission aimed at demonstrating the utility of solar sail for non-exhaustive propulsion. Solar sail is a thin, highly reflective sheet which utilizes solar thrust to propel itself forward. To maximize the solar thrust, orientations of the satellite will be actively controlled using 3-axis magnetorquer coils and a RW, mounted on a 3-phase BLDC motor in the pitch axis. The satellite's orientation control law, which is the outer control loop, demands a constant torque from RW during each iteration. This necessitates implementation of a fast and precise inner loop for controlling the torque from the BLDC motor. The methods presented are embodiment of simple yet effective torque control strategies suitable for implementation in a nano-satellite. Commercial-off-the-shelf(COTS) integrated half-bridge gate driver is used for switching the three phases of BLDC driver. The driver uses hall sensors to take position feedback for commutation, reducing the jerky start-up of RW which could potentially destabilize the satellite. The inner loop includes a Proportional-Integral(PI) controller which takes feedback from six unidirectional current sensors with precision rectifiers at their output. Two novel and generic methods of implementing

the PI controller have been thoroughly tested and presented. The first method employs analog components to generate the control signal using PI controller which is then converted into PWM signal of desired duty cycle and frequency. The PWM signal is fed to the driver IC which sets the motor speed proportional to the duty cycle. The system was modeled and simulated in the NI-Multisim environment and initial estimates of gains for PI controller were obtained. Fine tuning of gains was done through practical testing. The procedure and results are presented in the paper. In the second method, the PI controller has been implemented on a micro-controller and utilizes an in-built Analog to Digital Converter(ADC) to sample the current value which is then fed to a control loop implemented on the micro-controller. PWM is generated using the in-built timer module. The micro-controller requires high processing speed of the inner loop to ensure that it is significantly faster than the satellite's attitude control loop and should be tolerant to high energy radiation. Comparative analysis of both the methods to implement this control and the testing results are presented.