32nd IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Interactive Presentations - 32nd IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (IP)

Author: Dr. Muhammad Rizwan Mughal
Sultan Qaboos University (SQU), Oman

Mr. Hassan Ali
Institute of Space Technology (IST), Pakistan
Mr. Al Moulla Talal
Sultan Qaboos University (SQU), Oman

POWER OPTIMIZATION AND THERMAL ANALYSIS OF PRINTED COILS, COMPACT COILS, AND MAGNETIC RODS FOR CUBESAT ATTITUDE CONTROL

Abstract

Magnetorquers are essential for CubeSat attitude control, generating torque through electromagnetic interactions with Earth's magnetic field. However, the associated heat dissipation can impact performance, necessitating an optimized design for thermal efficiency.

This analysis examines the thermal behavior of three CubeSat-compatible magnetorquer configurations: printed coils, compact coils, and magnetic rods. Each configuration has distinct advantages in terms of integration, space utilization, and efficiency, but their thermal characteristics must be thoroughly evaluated to ensure reliable operation in space. By using mathematical modelling and experimental validation, this work aims to determine optimal design parameters that minimize heat generation while maximizing torque output.

The thermal response of printed coils is analyzed by varying parameters such as turn width, turn height, inter-turn spacing, applied voltage, and internal/external dimensions. These coils, embedded within the CubeSat's printed circuit board (PCB), offer a space-efficient alternative but pose thermal challenges due to limited heat dissipation paths. Compact coils, wound separately and integrated within the CubeSat structure, are examined by adjusting coil width, height, wire diameter, and insulation properties to evaluate their heat distribution and efficiency. For magnetic rods, the analysis considers the impact of wire diameter, rod length, and winding density on thermal performance, assessing the trade-off between increased magnetic moment generation and heat buildup. A comparative evaluation is conducted to determine the configuration that provides the best torque-to-heat ratio under operational constraints.

The results of this analysis offer key insights into the thermal management of CubeSat magnetorquers, supporting the selection of an optimal configuration for future small satellite missions. By presenting both experimental and simulated data on heat dissipation, this work contributes to the design of more efficient magnetorquer systems with improved operation and reliability. The final evaluation, including optimized design recommendations and key performance metrics, will be presented.