Modelling and Simulation of EIRSAT-1 Attitude Determination and Control System

J. Thompson, D. Sherwin, V. Ubeda, W. O'Connor

August 15, 2017

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1 Introduction

This document details initial modelling and simulation of the Attitide determination and Control System (ADCS) for EIRSAT-1. This includes a background theory section, details of the simulation environment and a number of simulation results representing different control modes and different mission profiles.

2 ADCS System Specification

2.1 Control Modes

- Detumble
- Nadir pointing
- Sun pointing
- Spin?
- Safe mode

2.2 ACDS Requirements

Max rate to detumble?

Required pointing accuracy?

Settling time?

2.3 Failure modes

Loss of sensor

Loss of actuator

3 Modelling

3.1 Co-ordinate systems and Reference Frames

The spacecraft moves in an inertial reference frame N with associated cartesian coordinate system $OXYZ$ where $\mathbf{n_1}$, $\mathbf{n_2}$ and $\mathbf{n_3}$ are unit vectors along the X, Y and Z axes respectively.

A second reference frame A is attached to the spacecraft rigid body with coordinate system $Cxyz$ where C is the mass centre of the rigid body and $\mathbf{a_1}$, $\mathbf{a_2}$ and $\mathbf{a_3}$ are unit vectors along the x, y and z axes respectively.

A third reference frame .... orbital frame

3.2 Satellite Dynamics

EIRSAT-1 is modelled as a single rigid body with 6-DOF (degrees of freedom). The satellite has mass m and inertia tensor I in the body fixed coordinate system

3.3 Rotational Kinematics

The attitude of the spacecraft is described by quaternions.

3.3.1 Alternative representations of attitude and conversions

The orientation of the spacecraft may also be described using a Direction Cosine Matrix.

The orientation of the spacecraft may also be described using Euler angles. Starting with the body-fixed $oxyz$ axes aligned with the $OXYZ$ axes, the body undergoes a sequence of rotations by angles θ_3, θ_2 and θ_1 about the body-fixed z (yaw), y (pitch) and x (roll) axes respectively to reach its final orientation.

The DCM (Direction Cosine Matrix) is then described by equation 1.

$$C = \tag{1}$$

3.4 Orbital Dynamics

3.5 Environment

3.5.1 Magnetic Field

3.5.2 Gravitational Field

3.6 Sensor Models

3.7 Actuator Models

4 Controller Design

4.1 Dynamics block

4.2 Environment block

4.3 Sensor block

5 Simulation Environment

Simulink Model Structure

5.1 Dynamics block

5.2 Environment block

5.3 Sensor block

5.4 Actuator block

5.5 Controller block

5.6 Reference block

5.7 Mode Select block

6 Running Simulations

6.1 Model Setup File

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