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Hawfinch: A cosmic ray detector for the use in a CubeSat

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Abstract

Cosmic radiation levels increase with altitude, which should be possible to observe during a rocket flight that targets an altitude of 3000 m using a Geiger-Müller (G-M) tube based detector. There is a broad number of commercial G-M tube based detection kits available, which, however, do not fulfill all the requirements to be used as part of the CubeSat payload of AVESII, a competition rocket by the Aerospace Team Graz (ASTG) [1]. Therefore, this thesis aims to design, build and characterize the cosmic ray detector Hawfinch that can be used.

First, the thesis outlines the theoretical foundations required to build such a detector and shows that it needs to be sensitive to gamma radiation. Secondly, it describes the system, the printed circuit board and firmware design. Finally, the characterization using an radioactive source which emits gamma radiation and a calibrated measurement unit as reference is described.

The characterization measurement showed that Hawfinch is sensitive to gamma radiation and can be used to detect cosmic rays during the flight of a rocket. Additionally, it fulfills all the requirements to be used inside a CubeSat as part of the payload of AVESII. Some improvements to the design of Hawfinch could lead to a future version with improved sensitivity or lower cost by using a different G-M tube or a custom high voltage generator.

Statutory Declaration

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Chapter 1

Introduction

Cosmic rays are high-energy particles from the sun, the solar system, or distant galaxies. When they hit the earth's atmosphere, they produce a shower of secondary radiation [2]. That radiation ultimately hits the earth's surface, where it can be detected even by low-cost Geiger-Müller (G-M) tube based detection kits.

It has been observed that the flux of radiation increases with altitude [3]. This increase should even be measurable during the flight of a rocket that targets an altitude of 3000 m using a G-M tube based detector.

The reason to perform this measurement is mainly scientific curiosity to see if the data captured by a G-M tube embedded in a self-made sensor system can be used to infer any of the flight parameters of the rocket like the altitude. By cross referencing the captured cosmic ray events and the flight data of the rocket, the effect that they might have on the flight sensors can be analyzed.

Sensor system must must fulfill the particular requirements proposed by the rocket mission it is designed to fly on. Unfortunately, commercially available detection kits that use G-M tubes usually do not fulfill those requirements.

This thesis will therefore describe the design and characterization of a sensor system named Hawfinch that embeds a G-M tube to detect cosmic rays during the flight of a rocket. Specifically, it should fulfill all the payload requirements of AVESII, a competition rocket by the Aerospace Team Graz (ASTG) [1], as will be specified in section 2.3.

The first section of this thesis will outline the theoretical foundations required to build the detector, the rocket environment and the requirements to the payload. In the next section the design of Hawfinch will be described and the characterization measurements will be outlined. Finally, the implementation of the finished detector and the results of the characterization measurement will be discussed.