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Control Electronics for High Wavelength Accuracy in a Nanosatellite Hyperspectral Imager

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Abstract

Nanosatellite-compatible miniaturized hyperspectral imagers must achieve excellent wavelength accuracy in order to provide data suitable for use in scientific missions. This paper presents the gap control of the Fabry-Perot interferometer (FPI) used in the hyperspectral imager of the nanosatellite Aalto-1. The imager uses the FPI as a variable band-pass filter by varying the gap between the mirrors. The distance between the mirrors is estimated by measuring the capacitance between three sets of electrodes positioned around the mirrors. Without temperature compensation, the gap controller was not able to keep the temperature drift of the gap within the specified limit of 0.3 nm/°C. The gap control loop was broken down into potential drift contributors, and the worst-case instability is estimated. The measured drift was larger than the estimated drift, probably due to deformation of the FPI substrates. Using a temperature compensation function in the instrument microcontroller software, the resulting drift was reduced by more than an order of magnitude, satisfying the requirement.

1. Introduction

Small satellites are generating a rapid change in the application of space technologies. Cost-efficient small satellites can form constellations, and together they can acquire data more flexibly than traditional satellites. This means significant new opportunities for Earth observation.

However, current sensing technologies developed for traditional large satellites are not suitable for use in small satellites, due to the size and mass of these instruments. Miniaturization of key sensing technologies presents a challenge for the development of suitable payloads.

VTT Technical Research Centre of Finland has developed piezo-actuated Fabry-Perot interferometer (FPI) tunable optical filters for various wavelength ranges from the ultraviolet to the thermal infrared. When combined with imaging sensors, this technology is able to create small, light-weight hyperspectral cameras. Unlike traditional satellites' push broom instruments, which require stable attitude control, these 2D snapshot hyperspectral imagers are able to operate on platforms with relaxed stability requirements, such as nanosatellites and UAVs.

The tunable Fabry-Perot interferometer used in these imagers essentially consists of two plane

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