Characterisation of a LCoS based Laser Beam Steerer for Applications in Free Space Optical SatCom in LEO

Executive Summary Report

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1. INTRODUCTION AND PURPOSE OF THIS DOCUMENT

This document presents a summary of the project Characterisation of a LCoS based Laser Beam Steerer for Applications in Free Space Optical SatCom in LEO, in order to produce the deliverable document Executive Summary Report (ESR).

2. ACRONYMS LIST

Acronym	Description
AD	Applicable Document. Document that should be included as deliverable.
BSM	Beam Steering Module
CGH	Computer Generated Hologram
DMD	Digital Micro-mirror Device
EBB	Engineering Breadboard
EM	Engineering Model
EMXYS	Embedded Instruments and Systems S.L.
ESA	European Space Agency
HUD	Head-Up Display
IoT	Internet of Things
KO	Kick Off
LC	Liquid Crystal
LCoS	Liquid Crystal on Silicon
Mbps	Megabits per second
OGS	Optical Ground Station
PAN	Parallel Aligned Nematic
RD	Reference Document. Public information used in this document as reference.
RF	Radiofrequency
SLM	Spatial Light Modulator
SWIR	Short-wave infrared
TTC	Telemetry and Tele-Command
VAN	Vertically Aligned Nematic

3. INTRODUCTION

To make possible the operation of high-performance payloads and instruments onboard small satellites, high-capacity communication units must be used to transmit the large data volumes to ground. From this premise, EMXYS has developed the ODALISS satellite platform, a high performance satellite bus including an optical communications unit, named ODALCOM. ODALCOM is an IR laser Free-Space communications transceiver based in an optical phase modulation principle for beam configuration and beam steering, instead of using traditional optomechanical elements like electric motor-driven steering mirrors, much more bulky and power consuming. The module designed for beam processing is called Beam-Steering Module (BSM), which its main element is the spatial light modulator (SLM), and the key part of this project.

4. APPLICATION SCENARIO

The application scenario for ODALISS satellite optical transceiver, and specifically for the laser beam steering module (BSM) is defined by the communications demands of small satellites operating as a constituent part of large constellations in LEO (so-called Megaconstellations) providing communication services, such as relay Store-And-forward stations for ground IoT terminals or obtaining Earth images to be sent to ground for further analysis.

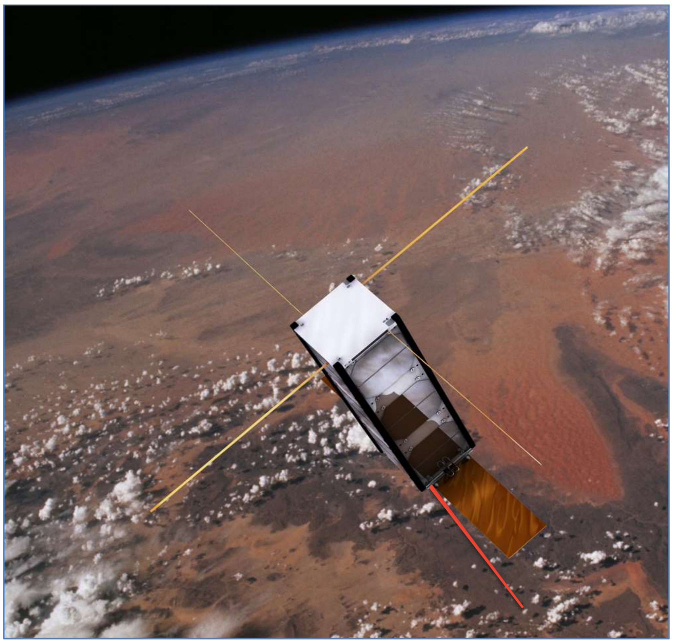

Fig. 1. ODALISS satellite platform rendition.

Specifically, satellite platforms that must handle and process large data volumes in what we name as “Data-Intensive applications” are the target for ODALISS laser communications terminal. To make possible the operation of high-performance payloads and instruments onboard small satellites, high-capacity communication units must be used to transmit the large data volumes to ground.

5. PROJECT SUMMARY

5.1 Key Elements

As mentioned, the key element is the Spatial Light Modulator (SLM). SLM are devices that are used to modulate light in amplitude, polarization or phase both in space and time domains. The base technology of the SLM used for this project is Liquid Crystal on Silicon (LCoS), that consist on a liquid crystal display over a silicon backplane so that part of the electronic processing can be integrated in the proximity of each pixel. Therefore, LCoS devices could be very small, micro displays, and integrate large displays (even 4K resolution) in very small formfactors. Obviously, this is highly interesting since, the larger the display (or light modulator surface) resolution, the more sophisticated could be the optical signal processing, including beam forming, beam steering or combination of both in a single mask.

Fig. 2. *SLM Hardware.*

5.2 Performed Tests

Initial characterization tests were performed to validate the correct operation of the SLM display. These tests consisted in 2 axis operation, nominal operation wavelength and HDMI interface were performed to demonstrate the basic operation of the SLM.

Besides, **functional tests** were executed, intended to verify the requirements defined for the project. In these tests the BSM **Maximum Angular Rate**, **Angular Resolution** and **Optical Power Efficiency** were verified in order to characterize the BSM operation. In these tests the capability of the BSM to steer the laser beam to its maximum angle, its minimum resolution angle and to operate above the optical power efficiency threshold at maximum angular deflection were verified.

Additionally, **environmental tests** were completed to check any possible deviation in the operation of the SLM. The environmental tests included BSM **Operational Temperature Range**, in which the BSM was submitted operational to 4 cycles from 0ºC to +70ºC, **Storage Temperature Range,** consisted in submitting the BSM non-operational to 2 consecutive cycles from -10ºC to +80ºC, and **Total Ionizing Radiation Dose,** submitting the BSM non-operational to a TID of 20 kRad of Ionizing radiation dose in a single step. After each environmental test, the verification of the correct performance of the BSM was made by submitting the SLM to the corresponding functional test, to check any change in the BSM operation.

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5.3 Test Results

The results of the Functional tests performed on the designed EBB and EM in the different work packages of the project validate that the BSM proposed meets the defined requirements for the intended application. Besides, Environmental tests comprising Thermal Vacuum test campaign and TID Radiation test campaign were performed, analysing later any change in the BSM operation. Any of the Tests affected the performance of the SLM in a relevant extent, thus maintaining the SLM its reflectance and efficiency values within a valid range. The conclusion is that the BSM is considered as fully functional for the application intended.

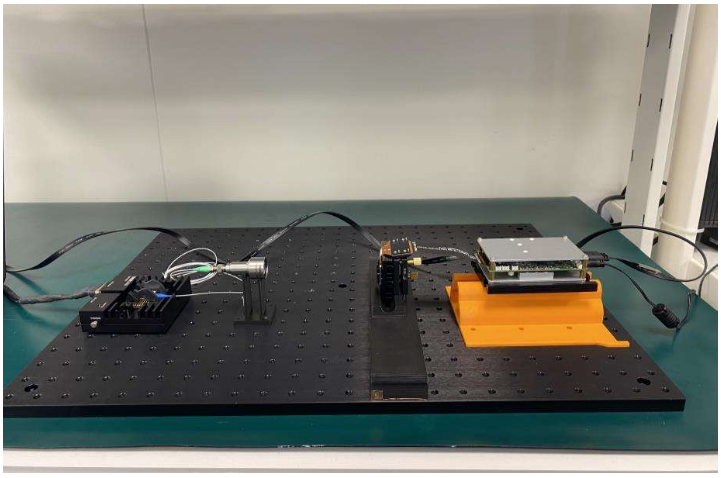

Fig. 3. Implemented Engineering Model of the BSM.

6. CONCLUSIONS

The aim of this activity was to validate the use of SLMs for beam configuration and beam steering for the communications demands of small satellites operating as a constituent part of large constellations in LEO providing communications services. Along this project a complete design and characterization of the BSM was designed to determine the SLM optical performance, along with the testbench used to cover the test campaign. An engineering and a breadboard model were developed and submitted to characterization tests. Besides, functional tests were performed over the SLM to demonstrate its basic operation as well as its optical characteristics, to later submit the element to environmental tests and analyse any change in its performance. Finally, a complete study of the results obtained from all the tests was accomplished, and the performance of the BSM was successfully demonstrated as well as its suitability for the intended application in space environment.