



EPS 2.0 Qualification Test Plan

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SpaceLab, Universidade Federal de Santa Catarina, Florianópolis - Brazil

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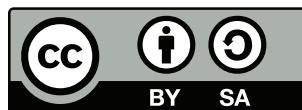
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CHAPTER 1

Introduction

This document presents a test plan for the qualification of the design of the EPS 2.0 module, developed for the FloripaSat-2 service platform, according to the requirements defined for the GOLDS-UFSC satellite.

The development of this document follow the guidelines and recommendations outlined in the EPS Test Plan Guidelines [1] document, which is based on the ECSS-E-ST-10-03 [2] standard for testing.

The test plan was prepared considering SpaceLab's laboratory and equipment as the test facility, and tests were selected based on that premise. For this reason, environmental tests were not included.

Multiple EPS designs are being developed at SpaceLab and there is an interest in performing performance comparisons between the different modules. With that in mind, this test plan will also include tests aimed at fulfilling the purpose of providing data for future performance comparisons.

1.1 Objectives

The objectives of this test plan are:

- The qualification of the design of the EPS 2.0 module, ensuring that the design of the module is capable of performing in accordance with its specifications.
- To generate data regarding the performance of this module for later comparison with different designs developed at SpaceLab.

CHAPTER 2

Hardware Models

For the execution of this test plan, dedicated qualification models of the EPS 2.0 were manufactured. Figure 2.1 and Figure 2.2 show the models as they were delivered to SpaceLab.

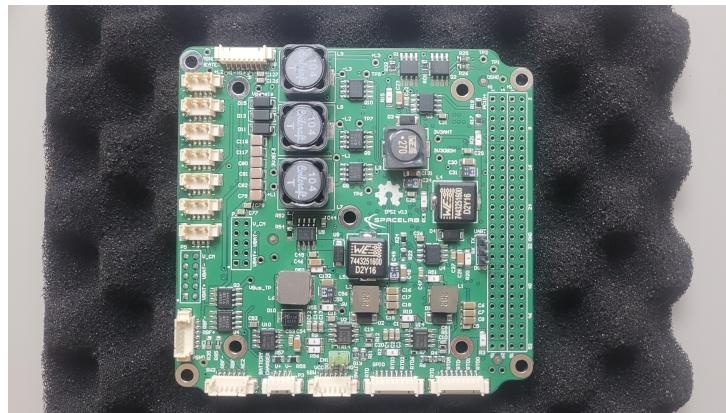


Figure 2.1: EPS 2.0 v0.3 top view.



Figure 2.2: EPS 2.0 v0.3 bottom view.

The models were manufactured with the version v0.3 of the hardware design, found in the EPS 2.0 GitHub repository [3]. The manufacturer used was PCBWay, and the models were delivered in February, 2024.

CHAPTER 3

Requirements to Verify

This test plan is intended to verify the requirements from the GOLDS-UFSC mission, associated the EPS 2.0 module. Those requirements are listed in Table 3.1. Along with its primary purpose, this test plan also aims to generate data for future performance comparison of the different EPS modules designed at SpaceLab, for this purpose an additional requirement was created (identified as REQ-PERF in Table 3.1) to represent this objective.

ID	Requirement
REQ-1	The power system must be able to harvest solar energy.
REQ-2	The power system must be able to store energy for use when GOLDS-UFSC is eclipsed.
REQ-3	The power system must supply energy to all other modules.
REQ-PERF	Generate data for future performance comparisons.

Table 3.1: Requirements to be verified.

CHAPTER 4

Test Programme

The test programme will follow the test matrix presented in Table 4.1, based on the baseline matrix provided in the EPS Test Plan Guidelines [1].

Test Block	Test Activity
Inspection	Manufacturing Inspection
	Electrical Inspection
	Mechanical Inspection
	Integration Inspection
Functional	Harvesting System
	Output Regulators
	Battery Management
	Output Control
	Protection Circuits
	Sensor Readings
Performance	Communication Buses
	Module Power Consumption
	Harvesting Regulator Efficiency
	Output Channels Regulators Efficiency
	Battery Charging Regulator Efficiency
Mission	Overall/System Efficiency
	Mission Cases
	Basic Execution Flow
	Payload Activation Schedule

Table 4.1: Test matrix

The baseline test matrix is organized in four test blocks: inspection, functional, performance and mission tests. In the next sections, a description of each block's objective and a list of the test activities and individual tests associated, will be presented.

Test specifications, procedures and reports will be identified through each test's ID in the respective documents.

4.1 Inspection

The Inspection test block has the objective of verifying the integrity of the manufacturing process and conformance of the physical model with the design files, ensuring there are no workmanship defects or flaws in the model. Table 4.2 lists the test activities and individual tests associated.

Activity	Test	ID
Manufacturing Inspection	Packaging quality and integrity assessment	INS-MAN-1
	Manufacturing standards assessment	INS-MAN-2
Mechanical Inspection	Board dimensions measurements	INS-MEC-1
	Board mass measurements	INS-MEC-2
	Mounting holes size and positioning	INS-MEC-3
Electrical Inspection	Components assessments	INS-ELE-1
	Solder quality and integrity assessment	INS-ELE-2
	Power bus continuity test	INS-ELE-3
	First power up procedure	INS-ELE-4
Integration Inspection	Connector pinout assessment	INS-INT-1
	Connector positioning assessment	INS-INT-2

Table 4.2: Inspection tests.

- Manufacturing Inspection:
 - has the purpose of verifying the integrity of the manufacturing and transportation processes;
 - consists of visual inspection of the packaging conditions and conformance to the fabrication standards requirements;
- Electrical Inspection:
 - has the purpose of verifying the electrical integrity of the module;
 - consists of verifying conformance with the electrical schematics, checking solder quality and integrity, checking for absence of short circuits and performing first power up of the module;
- Mechanical Inspection:
 - has the purpose of verifying the physical properties of the board in relation to the design files;
 - consists of measurements of board dimensions, mass, size and position of mounting holes;
- Integration Inspection:
 - has the purpose of verifying that the module can be physically integrated with the satellite;
 - consists of checking the connectors pinout and positioning in relation to the design files.

4.2 Functional

The Functional test block has the objective of verifying that the module is capable of executing all of its required functions according to its designed specifications.

Activity	Test	ID
Harvesting System	Boost converters test	FUN-HSYS-1
	MPPT algorithm test	FUN-HSYS-2
Output Regulators	EPS/TTC regulator test	FUN-OREG-1
	OBDH regulator test	FUN-OREG-2
	Antenna regulator test	FUN-OREG-3
	Radio 0 regulator test	FUN-OREG-4
	Radio 1 regulator test	FUN-OREG-5
	Payloads regulator test	FUN-OREG-6
Electrical Inspection	Components assessments	INS-ELE-1
	Solder quality and integrity assessment	INS-ELE-2
	Power bus continuity test	INS-ELE-3
	First power up procedure	INS-ELE-4
Integration Inspection	Connector pinout assessment	INS-INT-1
	Connector positioning assessment	INS-INT-2

Table 4.3: Functional tests.

- Harvesting System:
 - has the purpose of verifying the correct operation and functioning of the module's harvesting system;
 - consists of testing the relevant power converters as well as associated MPPT systems and algorithms;
- Output Channel Regulators:
 - has the purpose of verifying the correct operation and functioning of the output channels regulators;
 - consists of applying varying loads to the voltage regulators, according to the expected limits during mission operation;
- Battery Management:
 - has the purpose of verifying the correct operation end functioning of the battery management system;
 - consists of testing the associated regulators, verifying the operation of the monitoring systems, testing of the heating systems and associated algorithms;
- Output Channels Control:

- has the purpose of verifying the correct operation and functioning of the output channels control system;
- consists of testing the operation of the channel's power switches and correct functioning of regulator's enable pins;
- Protection Circuits:
 - has the purpose of verifying the correct operation and functioning of the modules protection circuits;
 - consists of the current limiting capabilities of power switches, integrated protections of regulators, batteries charging and discharging protections and associated algorithms;
- Sensor Readings:
 - has the purpose of verifying the correct operation and functioning of the sensors and the correctness of the readings;
 - consists of testing and comparison of the module's sensor readings against external measurement instruments;
- Communication Buses:
 - has the purpose of verifying the correct operation and functioning of the communication buses and integrity of information;
 - consists of checking the communication buses' configuration and protocols, verifying the integrity of the messages, including both external (for other modules) and internal (for peripherals) communication buses.

4.3 Performance

The Performance test block has the objective of verifying and evaluating the performance aspects of the module in relation to its requirements. The main focus of this block, considering an EPS module, is on evaluating the efficiency of the multiple conversion stages present in the module, as well as of the module as a whole. This usually consists of applying varying loads to the regulators and measuring input and output power consumptions in order to calculate the efficiency, resulting in an efficiency curve, providing data for different points of operation.

This test block is composed of the following activities:

- Module Power Consumption:
 - has the purpose of evaluating the power consumption of the isolated module, in normal operating conditions, with no loads connected;
- Harvesting System Efficiency:
 - has the purpose of evaluating the efficiency of the converters associated with the harvesting system;
- Output Regulators Efficiency:

- has the purpose of evaluating the efficiency of the converters associated with the output channels;
- Battery Charge Regulators Efficiency:
 - has the purpose of evaluating the efficiency of the converters associated with the batteries;
- System Efficiency:
 - has the purpose of evaluating the efficiency of the system as a hole, considering all conversion stages;

4.4 Mission

The Mission test block has the objective of verifying the correct operation of the module in relation to the mission concept of operations. The activities of this block will involve simulations of expected scenarios during mission operation, considering what is feasible to simulate on ground. These may include, for example, system initialization, payload activation schedule, eclipse situations and other relevant scenarios. It is also included simulations of contingency situations, and time critical scenarios. Due to the nature of this block, the test activities will be highly dependent on the specifics of each mission, and so no specific activities or scenarios are proposed at this moment.

4.5 Environmental

The Environmental test block has the objective of verifying that the module is capable of surviving and operating on the conditions of the environment it is exposed to.

The activities involve vibration tests, which relates to the launch conditions, and thermal vacuum, thermal cycling and bake-out tests, which relate to the space and orbit conditions; Specific details for these tests, including test levels and durations, are defined directly in the ECSS-E-ST-10-03 standard [2]. The requirements of the launch provider, when known, must also be taken into account and take precedence over the standards.

CHAPTER 5

Test Facilities

The test facility selected for the execution of this test plan is the SpaceLab's laboratory, located at Universidade Federal de Santa Catarina's campus in Florianópolis, and the tests were selected considering its infrastructure and available equipment.

Below is a list of equipment available at SpaceLab's laboratory:

- SpaceLab FlatSat Platform;
- Desk Power Supplies;
- Computers;
- SpaceLAb Interstage Interface Panel boards;
- Logic Analyzer;
- MSP-FET Flash Emulation Tools;
- USB-UART converters;
- General purpose measurement instruments:
 - Oscilloscope;
 - Digital multimeters;
 - Pachymeter;
- Protoboards;
- Electronic components;

CHAPTER 6

Documentation

Bibliography

- [1] Ramon de Araujo Borba. *EPS Test Plan Guidelines*. SpaceLab, February 2024.
- [2] ECSS Secretariat. ECSS-E-ST-10-03 – Testing. Technical Report Rev.1, ECSS-ESTE^C, 5 2022.
- [3] SpaceLab. Eps 2.0 github repository.