***\*Notice:***

***This file is an example based on generic satellite design and does not guarantee to be approved on the review process for launch or deployment. In accordance with design of each satellite, this document may have to be changed. Details of this template are subject to change without notice. Please change YELLOW sentence according to each satellite.***

***(本文書は標準的な設計の衛星を想定した一例であり、打上げ・放出のための審査プロセスでの承認を保証しているものではありません。各衛星の設計によって内容を変更する必要があります。また、本テンプレートの内容は予告なく変更される場合があります。黄色の箇所を各衛星に応じて変更してください。)***

[Satellite Name]

Vibration Test Report

Initial Release: DD/MM/YYYY

[Project Team Name]

Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Version | Date | Writer | Annotations |
| 1 | DD/MM/YYYY | XXX | Initial Release |
| 1.1 |  |  |  |
| 1.2 |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

Contents

[1. Purpose 1](#_Toc18314731)

[2. Applicable Document 1](#_Toc18314732)

[3. Test method 1](#_Toc18314733)

[**3.1.** **Test Objectives** 1](#_Toc18314734)

[**3.2.** **Acceleration measurement point** 2](#_Toc18314735)

[**3.3.** **Test Contents** 3](#_Toc18314736)

[**3.4.** **Vibration test level** 3](#_Toc18314737)

[**3.5.** **Test Tolerance** 4](#_Toc18314738)

[**3.6.** **Test Sequence** 5](#_Toc18314739)

[4. Test Results 6](#_Toc18314740)

[**4.1.** **Visual inspection** 6](#_Toc18314741)

[**4.2.** **Random Vibration Test** 9](#_Toc18314742)

[**4.2.1.** **X-axis vibration** 9](#_Toc18314743)

[**4.2.2.** **Y-axis vibration** 11](#_Toc18314744)

[**4.2.3.** **Z-axis vibration** 13](#_Toc18314745)

[**4.3.** **Natural frequency** 15](#_Toc18314746)

[**4.4.** **Function Test** 15](#_Toc18314747)

[5. Conclusion 16](#_Toc18314748)

# **Purpose**

This document summarizes the result of the Vibration Test for [Satellite Name] which will be deployed from JEM Small Satellites Orbital Deployer (J-SSOD).

# **Applicable Document**

1. JX-ESPC-101132-C JEM Payload Accommodation Handbook-Vol.8-

Small Satellite Deployment Interface Control Document

1. JMX-2011303 Structure Verification and Fracture Control Plan for JAXA

Selected Small Satellite Released from J-SSOD

1. [Document Number] Structure Fracture Control Evaluation Form for

Small Satellite deployed from J-SSOD

1. [Document Number] [Satellite Name] Flight Safety Assessment Report

for phase XXX

# **Test method**

The verification points are as follows,

1. No breakage in main structure
2. Main structure needs to satisfy specified natural frequency
3. Natural frequency before and after tests need to remain unchanged
4. No improper antenna deployment, and no malfunction to CubeSat
5. No breakage in grass material such as solar battery cover
6. No loosening in all fasteners

## **Test Objectives**

Table 3.1-1 shows test objectives of this vibration test.

Table 3.1-1 Test Objectives

|  |  |  |
| --- | --- | --- |
|  | Part Name | Quantity |
| 1 | [Satellite Name] | 1 |
| 1-1 | Solar panel cover grass | 8 |
| 1-2 | Camera lens | 1 |
| 1-3 | Torque mark | 24 |
| 1-4 | Antenna mechanism | 1 |

## **Acceleration measurement point**

Acceleration measurement points are shown in Figures 3.2-1 and table 3.1.



* ***Need to identify control sensor and reference sensor***
* ***Include coordinate system***

Figure 3.2-1　Acceleration measurement point (X-axis)



Figure 3.2-2　Acceleration measurement point (Y-axis)



Figure 3.2-3　Acceleration measurement point (Z-axis)

Table 3.2-1　Acceleration measurement points

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Measurement point | Measurement axis | Acceleration sensor | CH | Note |
| Control Sensor  (shaker) | 3-axis | XXX | C1 |  |
| 3-axis | XXX | C2 |  |
| Jig | 3-axis | XXX | J1 |  |
| 3-axis | XXX | J2 |  |
| Satellite  (X surface) | X | XXX | A1 |  |
| Y | XXX | A2 |  |
| Z | XXX | A3 |  |
| Satellite  (Y surface) | X | XXX | A4 |  |
| Y | XXX | A5 |  |
| Z | XXX | A6 |  |
| Satellite  (Z surface) | X | XXX | A7 |  |
| Y | XXX | A8 |  |
| Z | XXX | A9 |  |

## **Test Contents**

Following vibration tests were performed along X, Y and Z axes, respectively.

(1) Low level sinusoidal sweep（modal survey）

(2) Random vibration

## **Vibration test level**

1. Low level sinusoidal sweep (Modal Survey)

Low level sinusoidal sweep is adequate for model verification of simple structures with relatively rigid components, whose flexibility is confined to mounting bracketry or frequency isolation hardware. Test level in the modal survey is shown in Table 3.4.1-1.

Table 3.4.1-1 Modal survey vibration environment

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Frequency  [Hz] | Amplitude  [G] | Sweep Rate  [Oct/min] | Sweep Direction |
| Each axis | 20~2000 | 0.5\* | 1\* | Sweep up/Once |

\*: Other amplitudes or sweep rate are acceptable, provided all structural modes can be excited

1. Random Vibration

The random vibration test level is shown in Table 3.4.2-1, the level is the envelope of the environments for HTV, Space X Dragon and NG Cygnus (reference: JX-ESPC-101132). This test level was defined by Structure Fracture Control Evaluation Form.

Table 3.4.2-1 Random vibration test level

(Envelope of the environments for HTV, SpaceX Dragon and NG Cygnus)

|  |  |
| --- | --- |
| **Freq. [Hz]** | **PSD [G2/Hz]** |
| 20 | 0.015 |
| 25.6 | 0.027 |
| 30 | 0.08 |
| 80 | 0.08 |
| 133 | 0.04 |
| 200 | 0.04 |
| 2000 | 0.002 |
| Overall | 4.824 Grms |
| Duration | 1 min/axis |
| Direction | 3 axes each |

## **Test Tolerance**

**<Random Vibration Test>**

1. Overall [Grms] : ±1.5dB
2. PSD [G2/Hz] : ＋3.0dB / －1.0dB
3. Frequency [Hz]: larger one of ±2% or 1 [Hz]
4. Duration [sec]: ＋10% / －0%

## **Test Sequence**

Table 3.6-1 shows the test sequence.

Table 3.6-1 Test Sequence

|  | Test Contents |
| --- | --- |
| Before vibration test | Visual inspection of satellite |
| X-axis test\* | Random vibration test (without satellite) |
| Satellite setup |
| Modal survey |
| Random vibration test |
| Modal survey |
| Y-axis test\* | Random vibration test (without satellite) |
| Satellite setup |
| Modal survey |
| Random vibration test |
| Modal survey |
| Z-axis test\* | Random vibration test (without satellite) |
| Satellite setup |
| Modal survey |
| Random vibration test |
| Modal survey |
| After vibration test | Visual inspection of satellite |
| Function test of satellite |

\*: Order of direction can be changed

***\*Notice: Modal survey is not requirement. This test is recommended to verify actual natural frequency and dropped internal part.***

# **Test Results**

Date：DD/MM/YYYY-DD/MM/YYYY

Location：XXX

## **Visual inspection**

The visual inspection for the satellite was conducted before/after the test. And no breakage was found in the satellite after the test. Also, there was no breakage in the solar cell cover glass and camera lens. No loosening was found in all fasteners. There was no improper antenna deployment during and after the vibration. No malfunction occurred to CubeSat, either. Test results show in Table 4.1-1 and Figure 4.1-1 to Figure 4.1-6.

Table 4.1-1 Inspection Result

|  |  |  |  |
| --- | --- | --- | --- |
|  | Part Name | Quantity | Inspection Result |
| 1 | [Satellite Name] | 1 | Pass |
| 1-1 | Solar panel cover grass | 8 | Pass |
| 1-2 | Camera lens | 1 | Pass |
| 1-3 | Torque mark | 24 | Pass |
| 1-4 | Antenna mechanism | 1 | Pass |

 

Figure 4.1-1 Photo on the +X surface (Left: before test Right: after test)

 

Figure 4.1-2 Photo on the -X surface (Left: before test Right: after test)

 

Figure 4.1-3 Photo on the +Y surface (Left: before test Right: after test)

 

Figure 4.1-4 Photo on the -Y surface (Left: before test Right: after test)

 

Figure 4.1-5 Photo on the +Z surface (Left: before test Right: after test)

 

Figure 4.1-6 Photo on the -Z surface (Left: before test Right: after test)

## **Random Vibration Test**

### **X-axis vibration**

Acceleration at control sensor resulted to be met requirement of vibration level. Also, acceleration data measured by modal survey before/after random vibration are same. Test results show in Figure 4.2.1-1 to Figure 4.2.1-5.



Add Photo

Figure 4.2.1-1　 X-axis Test Configuration with Test Jig only



Add graph of acceleration at control sensor

* + - * Test target does NOT include satellite.
* X axis: Frequency, Y axis: PSD
* Include upper limit and lower limit of tolerance
* PSD should be within upper and lower limit.

Figure 4.2.1-2　X-axis Vibration at Control Sensor with Test Jig only



Add Photo

Figure 4.2.1-3　X-axis Test Configuration with Satellite

Add graph of acceleration at control sensor

* + - * Test target include satellite.
* X axis: Frequency, Y axis: PSD
* Include upper limit and lower limit of tolerance
* PSD should be within upper and lower limit.



Figure 4.2.1-4　X-axis Vibration at Control Sensor with Satellite

Add graph of acceleration at sensor on satellite

* X axis: Frequency, Y axis: acceleration
* Indicate value of natural frequency



Figure 4.2.1-5　Modal Survey before Vibrating X-axis at Mesurement Point

(Left: before, Right: after)

### **Y-axis vibration**

Acceleration at control sensor resulted to be met requirement of vibration level. Also, acceleration data measured by modal survey before/after random vibration are same. Test results show in Figure 4.2.2-1 to Figure 4.2.2-5.



Add Photo

Figure 4.2.1-1　 Y-axis Test Configuration with Test Jig only



Add graph of acceleration at control sensor

* + - * Test target does NOT include satellite.
* X axis: Frequency, Y axis: PSD
* Include upper limit and lower limit of tolerance
* PSD should be within upper and lower limit.

Figure 4.2.1-2　Y-axis Vibration at Control Sensor with Test Jig only



Add Photo

Figure 4.2.1-3　Y-axis Test Configuration with Satellite

Add graph of acceleration at control sensor

* + - * Test target include satellite.
* X axis: Frequency, Y axis: PSD
* Include upper limit and lower limit of tolerance
* PSD should be within upper and lower limit.



Figure 4.2.1-4　Y-axis Vibration at Control Sensor with Satellite

Add graph of acceleration at sensor on satellite

* X axis: Frequency, Y axis: acceleration
* Indicate value of natural frequency



Figure 4.2.1-5　Modal Survey before Vibrating Y-axis at Mesurement Point

(Left: before, Right: after)

### **Z-axis vibration**

Acceleration at control sensor resulted to be met requirement of vibration level. Also, acceleration data measured by modal survey before/after random vibration are same. Test results show in Figure 4.2.3-1 to Figure 4.2.3-5.



Add Photo

Figure 4.2.1-1　 Z-axis Test Configuration with Test Jig only



Add graph of acceleration at control sensor

* + - * Test target does NOT include satellite.
* X axis: Frequency, Y axis: PSD
* Include upper limit and lower limit of tolerance
* PSD should be within upper and lower limit.

Figure 4.2.1-2　Z-axis Vibration at Control Sensor with Test Jig only



Add Photo

Figure 4.2.1-3　Z-axis Test Configuration with Satellite

Add graph of acceleration at control sensor

* + - * Test target include satellite.
* X axis: Frequency, Y axis: PSD
* Include upper limit and lower limit of tolerance
* PSD should be within upper and lower limit.



Figure 4.2.1-4　Z-axis Vibration at Control Sensor with Satellite

Add graph of acceleration at sensor on satellite

* X axis: Frequency, Y axis: acceleration
* Indicate value of natural frequency



Figure 4.2.1-5　Modal Survey before Vibrating Z-axis at Mesurement Point

(Left: before, Right: after)

## **Natural frequency**

Natural frequencies for each axis was identified based on the peak of PSD at modal survey shown in section 4.2. The natural frequencies are shown in Table 4.3-1. Rigidity required for CubeSat is equal to or more than 100Hz, and the test satisfies the requirement. In addition, the test data is almost same as analysis result.

Table 4.3-1 Natural frequency measurements

|  |  |  |  |
| --- | --- | --- | --- |
|  | X-axis | Y-axis | Z-axis |
| Natural frequency > 100 [Hz] | 420 | 800 | 400 |
| Analysis (ref.) [Hz] | 420 | 800 | 400 |

## **Function Test**

There was no failure or abnormal status on the voltage of battery and health data of the OBC (On-Board Computer) after vibration test. The satellite had no damage from vibration environment.



Add Photo

Figure 4.4-1　Function Test Configuration

# **Conclusion**

No distortion or damage were found on [Satellite Name] and on the solar battery by visual inspection, and no malfunction during and after the vibration were found. No loosening was found in the fastener which constitute a main structure. Moreover, no breakage of the solar cell cover grass and camera lens were found based on visual inspection after the vibration.

And this test verifies that the natural frequency at the lowest order of [Satellite Name] was higher than 100Hz which satisfies the JAXA specified rigidity requirement.