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OrigamiSat-2
CW Downlink Communication Data Format

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Revision History

Date	Revision No.	Change Description	Updated by
2025/10/1	Ver. 0	Initial version created	Ochi
2026/02/12	Ver. 0.1	Revised version created	Fukuda
2026/04/19	Ver. 1.0	Formatting adjusted	Sakamoto
2026/04/20	Ver. 1.1	Figure text revised	Fukuda

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1. Overview

This specification document describes the data format for CW (Constant Wave, Continuous Wave) communications of the 3U CubeSat OrigamiSat-2 (JS1YRU).

2. Communication Format

This section describes the CW communication data (telemetry) format. Table 1 shows an overview of the CW communication data format. The CW transmission speed is 120 cpm, and CW is transmitted in the order of call sign, satellite name, and data section.

The data section items and data volumes are shown in Table 2. The data section is transmitted in the order of the No. listed in Table 2. Note that all data is transmitted in hexadecimal (HEX).

Table 1 CW Downlink Communication Data Format

Call Sign	Satellite Name	Data Section
JS1YRU	ORIGAMI2	28byte

Table 2 Data Section Items and Data Volume

No	Data Section Items		Data Volume
1	Satellite Mode		1 byte
2	Battery Voltage		1 byte
3	Battery Current		2 byte
4	Battery Temperature		1 byte
5	Power Generation Status		1 byte
6	Switch Information		1 byte
7	Angular Velocities	X-Axis	1 byte
8		Y-Axis	1 byte
9		Z-Axis	1 byte
10	The Final Executed Command ID (OBC)		1 byte
11	The OBC Command Execution Result		1 byte

12	The Final Executed Command ID (ADCS)		1 byte
13	ADCS Mode		1 byte
14	The Final Executed Command ID (Raspi)		1 byte
15	Bus Communication Unit Temperature		1 byte
16	CBand Transmitter Temperature		1 byte
17	The OBC Startup Count		1 byte
18	The Number of Reservation Commands		1 byte
19	Satellite Time		4 byte
20	UVC Thesholds	Switch to Normal Mode Thesholds	1 byte
21		Switch to Normal Mode Thesholds	1 byte
22		Level 1 Thesholds	1 byte
23		Level 2 Thesholds	1 byte
24	The Number of Bus Communication Fuse Cuts		1 byte

Note:
OBC
- On Board Computer. A computer for sending and receiving commands and telemetry, switching the power status of various devices, and performing other functions.

ADCS
- Attitude Determination and Control System. Subsystem for estimating and controlling satellite attitude.

Raspi
- The single-board computer (Raspberry Pi 3B) installed for camera imaging

UVC
- Under Voltage Control. Function to transition satellite mode based on battery voltage

Note that all data is in big-endian format. The layout of components such as the OBC, ADCS, Raspi, and communication equipment is shown in Figure 1, while the system diagram is shown in Figure 2.

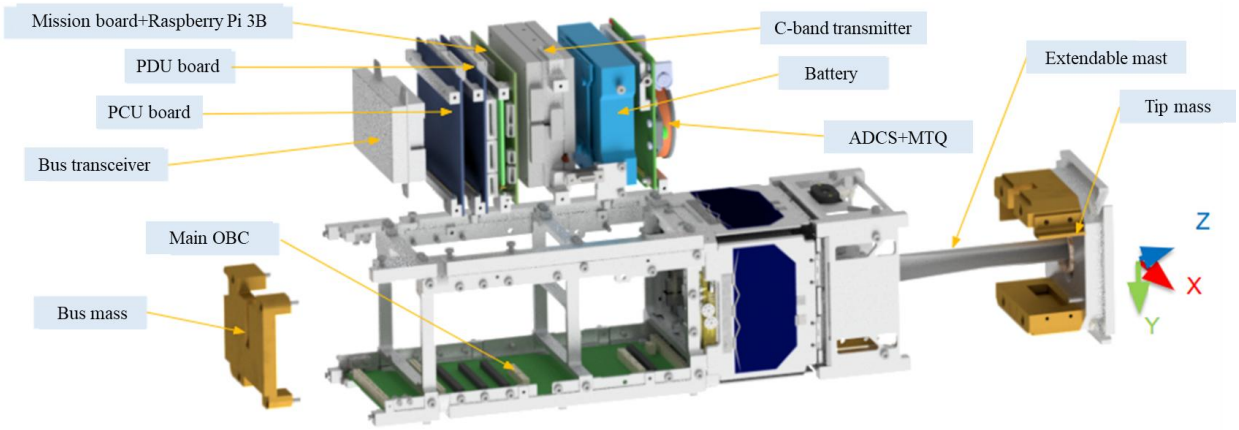

Figure 1 OrigamiSat-2 layout of components

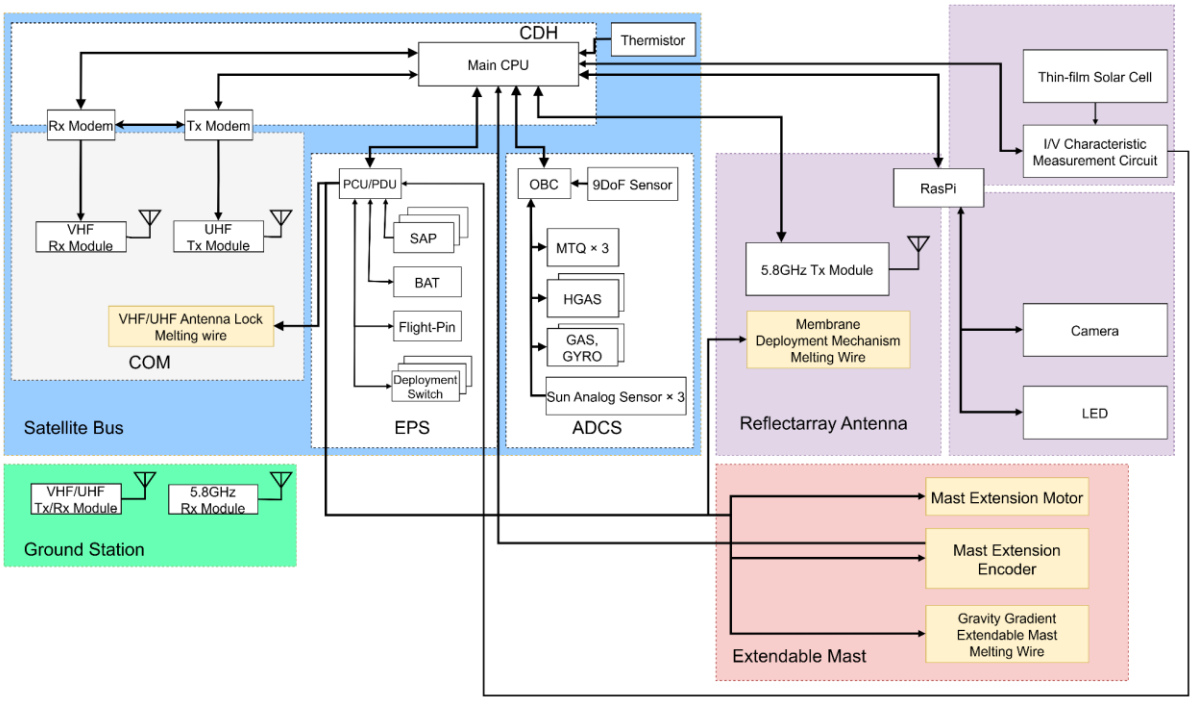

Figure 2 OrigamiSat-2 system diagram

Below, we describe the details of each item in the data section of Table 2.

2.1. Satellite Mode

The information sent to satellite mode is shown in Table 3.

Table 3 Breakdown of Sattelite Mode

7 bit	6 bit	5 bit	4 bit	3 bit	2 bit	1 bit	0 bit
UVC Enabled Status	UVC Level			Operating Mode Status	Operating Mode ID		

The UVC enabled status indicates deactivation when 0 and activation when 1. The UVC level notation is as shown in Table 4.

Table 4 UVC level Notation

UVC Level	6 bit	5 bit	4 bit
UVC startup successful	0	0	0
Level 1	0	0	1
Level 2	0	1	0
Switch to Normal Mode	0	1	1
Switch to Safe Mode	1	0	0

Figure 3 shows an overview diagram of UVC. When UVC is enabled, the UVC level initially indicates "UVC Startup Successful." Subsequently, it transitions through the following four levels based on battery voltage and the current UVC level.

Level 1

- When the current battery voltage falls below the Level 1 threshold (7.2V in Figure 3), and the current UVC level is either "UVC Startup Successful" or "Switch to Normal Mode".

Level 2

- When the current battery voltage falls below the Level 2 threshold (6.2V in Figure 3), and the current UVC level is either "Level 1" or "Switch to Safe Mode".

Switch to Normal Mode

- Current battery voltage exceeds the Normal Mode Transition threshold (7.5V in Figure 3), and the current UVC level is either "Level 1" or "Switch to Safe Mode".

Switch to Safe Mode

- Current battery voltage exceeds the Safe Mode Transition threshold (6.6V in Figure 3), and the current UVC level is "Level 2".

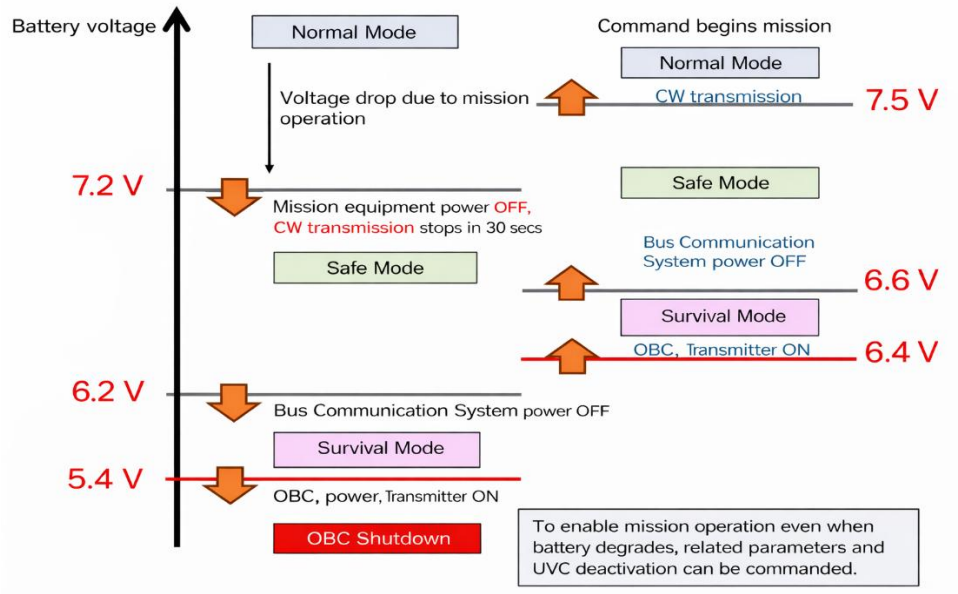

Figure 3 Overview diagram of UVC

The operational mode status indicates whether the operational state is currently in a transition state. A value of 0 indicates the transition is complete, while a value of 1 indicates the operational state is in transition. The operational mode ID represents the current satellite mode. Details for each mode are shown in Table 5.

Table 5 Details of Operational Mode

Mode	Details
Safe Mode	Low Battery Voltage Mode. Power off all equipment except bus communication-related devices and transmit CW at 30-second intervals.
Normal Mode	Nominal State Mode. Transmit CW at 3-second intervals. Activate mission equipment via commands to execute missions.
Survival Mode	Further Low Battery Voltage Mode. Power off all equipment except the OBC and receiver to focus solely on power recovery.
Initial Mode	Post-satellite deployment mode. Deploys UHF/VHF antennas and attempts to establish communication.

Each operational mode is represented as shown in Table 6.

Table 6 Notation for Each Operational Mode

Operational Mode	2 bit	1 bit	0 bit
Safe Mode	0	0	0
Normal Mode	0	0	1
Survivl Mode	0	1	0
Initial Mode	1	1	0

2.2. Battery Voltage

The battery voltage is stored as the value acquired by the PIC microcontroller from the AD converter. The battery voltage can be calculated by converting the received data (HEX) to decimal (DEC) and then using the following formula.

$$\text{Battery voltage}\,[\text{V}] = \frac{\text{Data}(\text{DEC})}{16} \qquad (1)$$

2.3. Battery Current

The battery current can be calculated using the following formula after converting the received data (HEX) to decimal (DEC).

$$\text{Battery current}\,[\text{A}] = \frac{\text{Data(DEC)} - 32767}{10.9225} \qquad (2)$$

2.4. Temperature Data

Battery temperature (No.4), bus communication unit temperature (No.15), and CBand transmitter temperature (No.16) can be calculated using the following formula after converting the received data (HEX) to decimal (DEC).

$$\text{Temperature data}\,[℃] = \text{Data(DEC)} - 128 \qquad (3)$$

2.5. Power Generation Status

Power generation status indicates whether the solar cell (SAP) is generating electricity. Details of the power generation status are shown in Table 7. A value of 1 for each bit indicates power generation is occurring, while a value of 0 indicates no power generation is occurring.

Table 7 The Details of Power Generation Status

5～7 bit	4 bit	3 bit	2 bit	1 bit	0 bit
0	SAP y+, -	SAP x-	SAP z-	SAP z+	Thin-film solar cell

Figure 4 shows the satellite's appearance with SAPs installed and the names of each SAP. The blue panels shown in the figure represent the SAPs. The SAP Zp surface unfolds facing the Zp surface during membrane deployment, as shown in Figure 5.

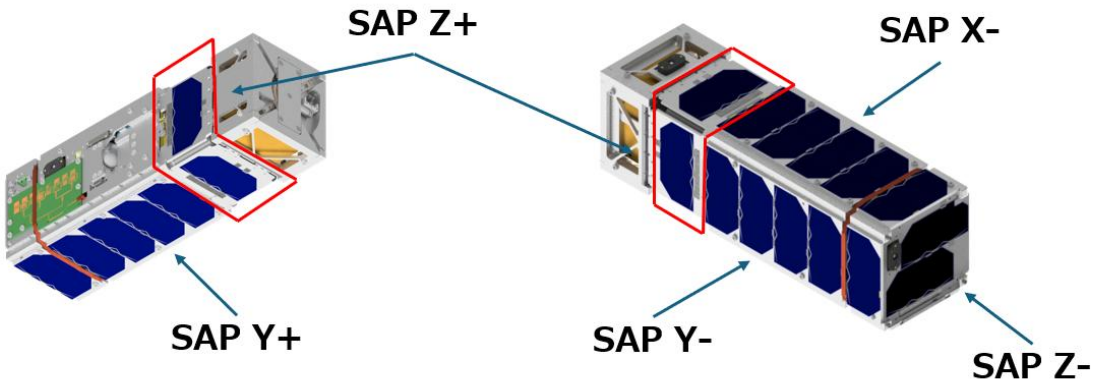

Figure 4 Satellite's Appearance and Names of Each SAP

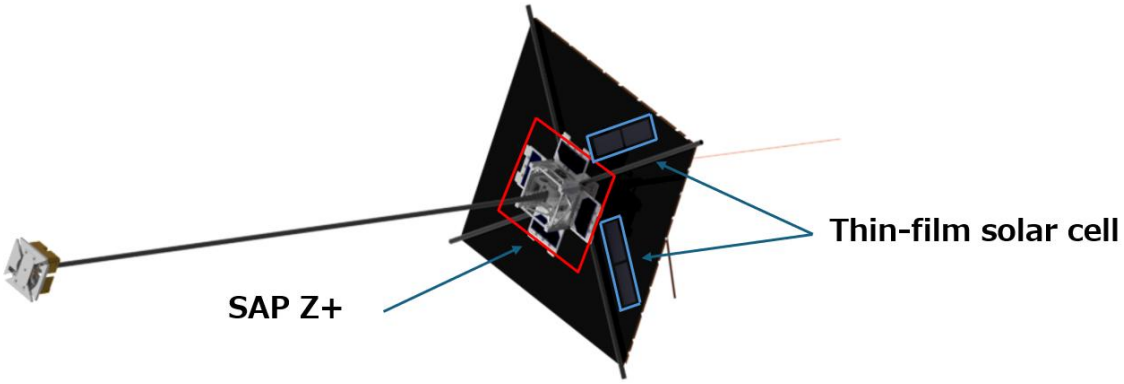

Figure 5 Appearance of The Satellite After Deployment

2.6. Switch Information

Switch information is used to monitor each power supply's power-on status. The meaning of each bit is shown in Table 8. For each bit, a value of 1 indicates on, while a value of 0 indicates off.

Table 8 Switch Status

7 bit	6 bit	5 bit	4 bit
CBand Transmitter	Extension mast	ADCS	Camera
3 bit	2 bit	1 bit	0 bit
Bus Communication Fuse Cuts	TFSC_IV	NO USE	IMU

Note:
TFSC_IV
- Used for the power supply of the thin-film solar cell IV characteristic measurement circuit.

IMU
- Inertial Measurement Unit. This device acquires angular velocity, geomagnetic, and acceleration information.

2.7. Angular Velocities

The angular velocities are stored in the order of X-axis, Y-axis, and Z-axis, starting from the high-order byte. Each angular velocity can be calculated using the following formula after converting the received data (HEX) to decimal (DEC).

$$\text{Angular velocities}\left[\text{deg/s}\right] = \frac{\text{Data(DEC)}}{10} - 12.7 \qquad (4)$$

2.8. The Final Executed Command ID

During command uplink from the ground station, each command is assigned a sequential ID (command ID) ranging from 0x00 to 0xFF. The final executed command ID here indicates the ID of the last command executed by the OBC, ADCS, and Raspi.

2.9. The OBC Command Execution Result

The command execution result indicates the status of the command executed by the OBC. The interpretation method is not disclosed.

2.10. ADCS Mode

ADCS mode indicates the current attitude control status. Details of each mode are shown in Table 9.

Table 9 Detail of ADCS Mode

Data（HEX）	ADCS Mode	Details
0x00	START UP	Initialization state immediately after powering on the ADCS
0x01	INITIAL	Mode performing only attitude estimation without moving the MTQ (Nominal).
0x02	BDOT	B-dot control mode for detumbling. Attitude estimation is also performed simultaneously.
0x04	3AXIS	Cross-product control mode for geocentric pointing control. Attitude estimation is also performed.
0x06	RMMEST	Mode performing residual magnetic moment (RMM) estimation.
0x07	EARTHPOINT	Improved B-dot control mode for geocentric pointing control. Attitude estimation is also performed.

2.11. OBC Startup Count

The OBC startup count indicates how many times the OBC has restarted. However, if the count exceeds 255, it resets to 0. The value obtained by converting the data (HEX) to decimal (DEC) directly represents that data.

2.12. Number of Reservation Commands

The number of reservation commands indicates the number of reservation commands registered on the satellite. The value converted from data (HEX) to decimal (DEC) directly represents that data.

2.13. Satellite Time

Satellite time represents the satellite's time in UNIX time. The value obtained by converting the 4-byte data (HEX) to decimal (DEC) directly indicates that data.

2.14. UVC Thresholds

The UVC thresholds, starting from the upper byte, are as follows: the threshold for transitioning to Normal mode, the threshold for transitioning to Safe mode, the threshold for UVC Level 1, and the threshold for UVC Level 2. Each value can be calculated by converting the received data (HEX) to decimal (DEC), then applying the following formula.

$$\text{UVC thresholds}\,[\text{V}] = \frac{\text{Data}(\text{DEC})}{10} \tag{5}$$

2.15. Number of Bus Communication Fuse Cuts

The number of bus communication fuse cuts indicates how many times the fuse was cut to activate the deployable antenna. The value converted from data (HEX) to decimal (DEC) directly represents that data.

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