BIRDSX-SAR-01

BIRDS-X Project
Flight Safety Assessment Report
for Phase 0/I/II

Note

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Rev. F : July 22, 2024

Kyushu Institute of Technology

REVISION HISTORY

REV.	DATE	Writer	DESCRIPTION
NC	2023/12/27	TIM Hoksong	Initial Release
A	2024/1/29	TIM Hoksong/Kohnosuke Yamaguchi	Add LED/Fixes
B	2024/3/22	Yudai Etsunaga	Final fixes
C	2024/04/10	Yudai Etsunaga	Status fixes
D	2024/06/17	Yudai Etsunaga	Appendix B-1 Status fixes
E	2024/07/05	Yudai Etsunaga	Added more explanation on the Kapton tape extension in 3.2.2
F	2024/07/22	Yudai Etsunaga	Fixed 3.2.2

Table of Contents

1 Introduction

1.1 Purpose

The purpose of this Safety Assessment Report (SAR) is to verify identification and description of the hazards regarding DRAGONFLY for Phase 0/I/II.

1.2 Scope

The scope of this document is to show safety design and verification results of DRAGONFLY from its launch to deployment from ISS.

1.3 Applicable Documents

(1) JSX-2023030	BIRDS バスを使用した小型衛星向け簡易 SAR による安全審査実施要領
(2) 29_BIRDS5_SAR-03	[BIRDS-5] Flight Safety Assessment Report for Phase III
(3) JX-ESPC-101132E	JEM Payload Accommodation Handbook Vol.8 Small Satellite Deployment Interface Control Document

2 Safety Analysis Methodology

2.1 Methodology

Safety analysis has been performed in accordance with SSP30599. In addition, the Cubesat uses BIRDSBus, which meets design constraints in Applicable Document (1). Therefore, the safety analysis has also been performed based on Applicable Document (1).

Compliance with ISS Jettison Policy are evaluated by J-SSOD system integrator in "Safety Assessment Report for series product."

2.2 Safety Requirements

Following safety requirements are applied.

(1) SSP51721 ISS Safety Requirement Document

(2) PPD1101 ISS Jettison Policy

(3) SSP30599 Safety Review Process

3 System Description

3.1 Overview

DRAGONFLY is 2U CubeSat whose dimension is 100 mm x 100 mm x 227 mm and weight is less than 2.66 kg. External views of DRAGONFLY in its stowed configuration and deployment configuration are shown in Figure 3.1-1 and Figure 3.1-2, respectively.

DRAGONFLY mission objectives are as follows.

- Alternative UHF TRX

  The objective is to develop and demonstrate an alternative UHF TRX for CubeSat that offers comparable performance, data rate, and low power consumption as the existing commercial one. Our proposed TRX costs approximately 300 USD, thus providing a cost-effective solution for future CubeSat projects, ensuring reliable communication capabilities while minimizing financial constraints.

- Volcano Monitoring (APRS-R)

  This mission aims to operate the APRS Reference payload in the store-and-forward mode to carry the acquired data from the remote volcanic area and observe and monitor the volcanic activity by analyzing the collected data through the satellite.

- APRS Payload competition (APRS-P)

  The objective of this mission is to increase the users of the amateur radio community by providing APRS payload slots, as well as helping people to get involved in the creation and operation of that payload, resulting in the improvement of their technical skills and democratization of space. The ground terminal used for APRS was selected through a contest. With various configurations, conditions, and hardware, the APRS payload in DRAGONFLY will be thoroughly tested.

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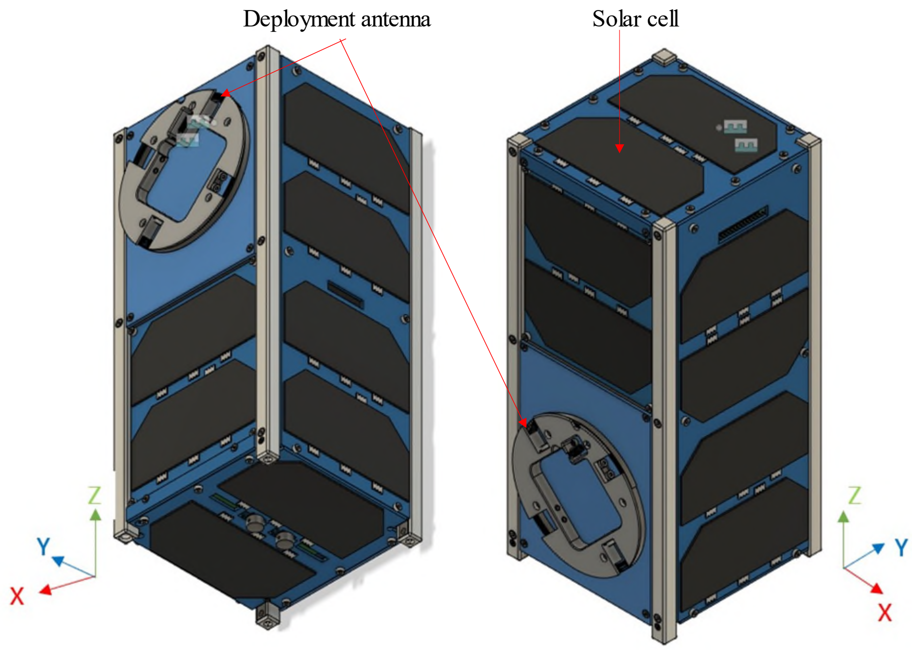


Figure 3.1-1 DRAGONFLY stowed configuration

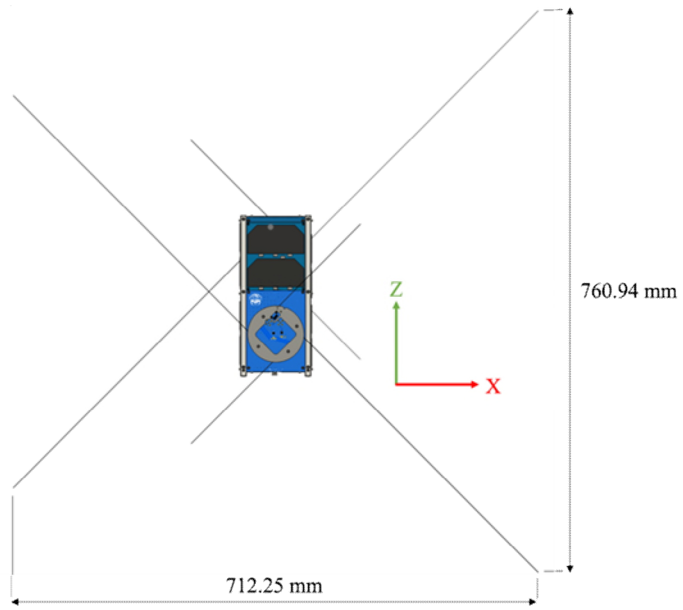


Figure 3.1-2 DRAGONFLY deployment configuration

The system block diagram of DRAGONFLY is shown in Figure 3.1-3. The OBC (On Board Computer) / EPS (Electrical Power System), FAB (Front Access Board), BPB (Backplane Board) design is based on BIRDSBus (refer to https://birdsopensource.github.io/).

The following is information for BIRDSBus used in DRAGONFLY:

- The used BIRDSBus: OBC/EPS, FAB, BPB
- BIRDSBus version: version 4
- Modification: Yes – Since the satellite size was set to 2U, the outer panels on the X and Y sides were divided into two panels, upper and lower. BIRDSBus had a blocking diode on the FAB. However, since the ±X panel is divided into upper and lower panels, blocking diodes are placed on each panel and diodes for ±X on the FAB are replaced with 0 ohm resistors. Diodes on the panel are identified as an inhibitor of battery over-discharge.

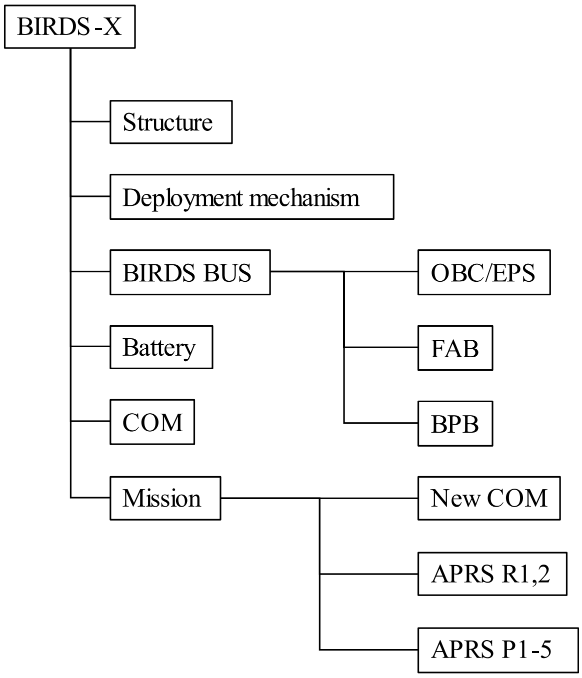


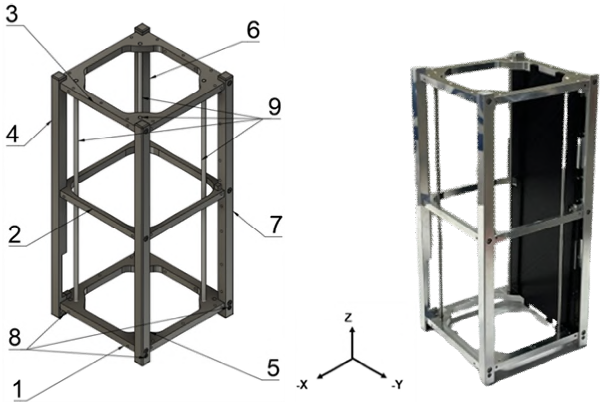
Figure 3.1-3 The system block diagram of DRAGONFLY

3.2 Design Different from Baseline

In this section, design difference of DRAGONFLY from BIRDS-5 (PearAfricaSat-1 and ZIMSAT-1) in Applicable Document (2) is described.

3.2.1 Structure

Figure 3.2.1-1 and Figure 3.2.1-2 shows the primary structure (4 rails and 3 frames) and internal configuration, respectively. The size is 2U, but the whole structure design is different. The primary structure is made of Aluminum alloy A6061-T6 and all four rails are hard anodized. Other structural parts are treated with Alodine. These parts are not welded, forged, cast or quenched.



Parts List		
1	1	Frame -Z
2	1	Frame 0Z
3	1	Frame +Z
4	1	Rail –Y/-X
5	1	Rail +Y/-X
6	1	Rail +Y/+X
7	1	Rail -Y/+X
8	3	Deployment switch
9	4	Rod

Figure 3.2.1-1 The primary structure (4 rails and 3 frames)

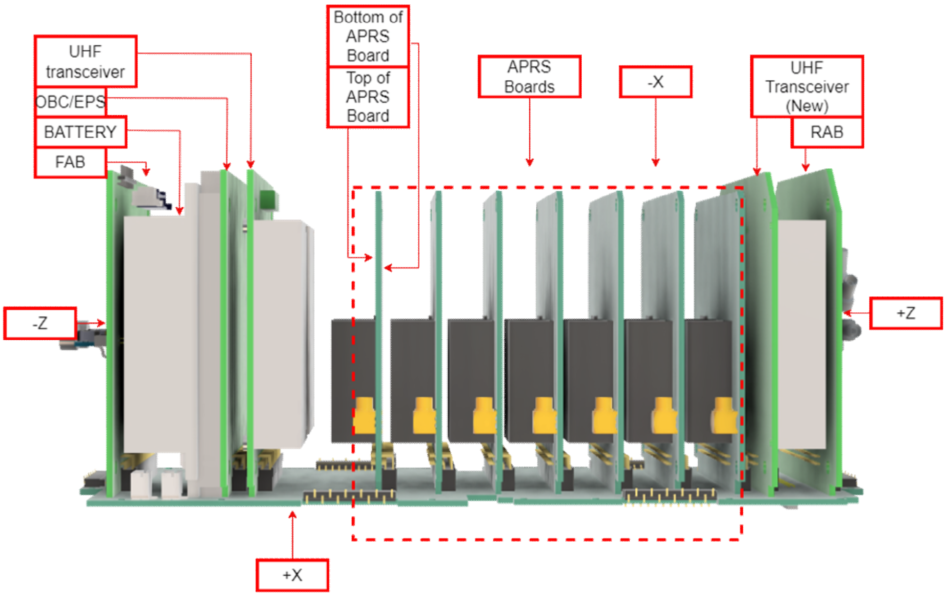


Figure 3.2.1-2 The internal configuration

3.2.2 Deployment Mechanism

DRAGONFLY has eight deployable antennas, which are dipole type for UHF and VHF transmitter. Figure 3.2.2-1 shows stowed antenna configuration. The parts used (UHF antenna (225mm x 3mm x 0.3mm), VHF antenna (487mm x 3mm x 0.3mm), wire (PE line), heat cutter) are the same as BIRDS-5. On the other hand, we created a new Teflon antenna deployment mechanism to prevent the wire from getting caught in the antenna after cutting. In BIRDS-5, the UHF antenna was covered by a VHF antenna. At DRAGONFLY, the antenna is held in place by a Kapton tape extension attached to the tip of the VHF antenna; the UHF and another VHF antenna are covered by this. Kapton tape extension is created by laminating two wires with Kapton tape. Two independent wires are tied to this Kapton tape extension and to the antenna tip and antenna deployment mechanism with two half-hitch knots. Figures 3.2.2-2 through 3.2.2-5 show the details. The contact area with the other parts is chamfered and covered with Kapton tape. (See BIRDS-X Assembly Drawing and BIRDS-X Assembly Procedure Step #14 in the details.) Collision analysis immediately after deployment from J-SSOD is performed. (See Appendix C-9.)

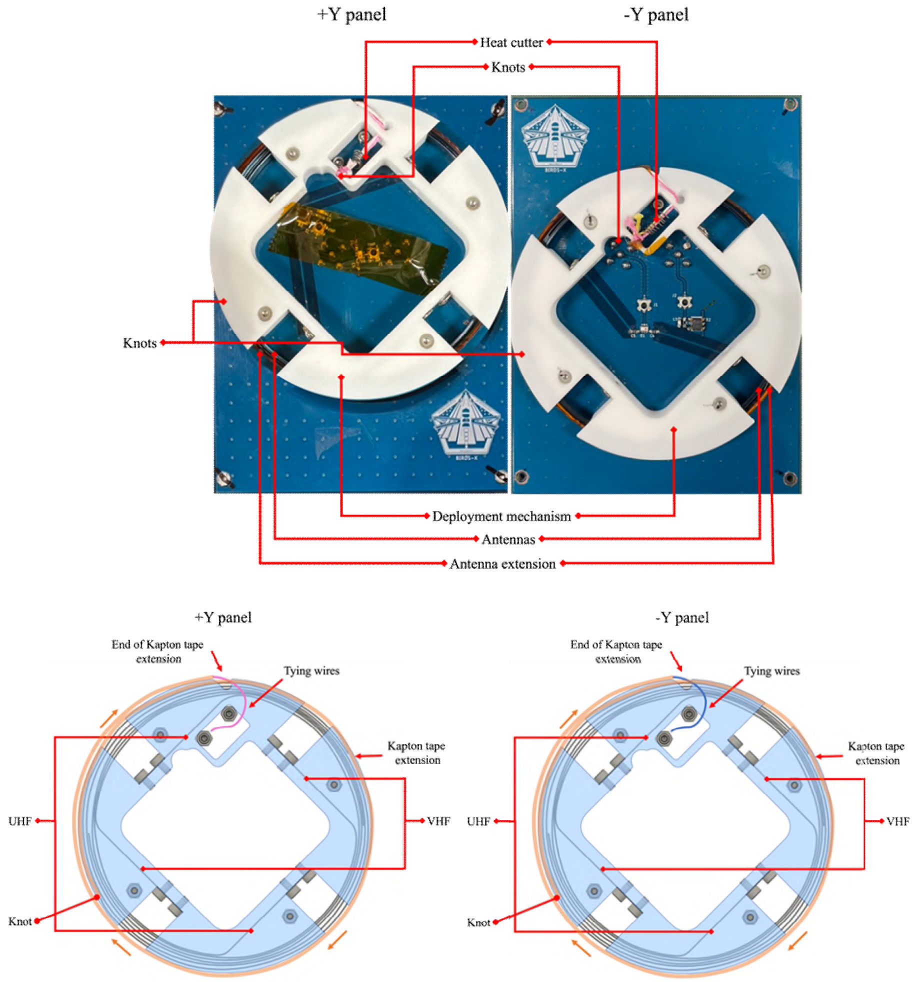
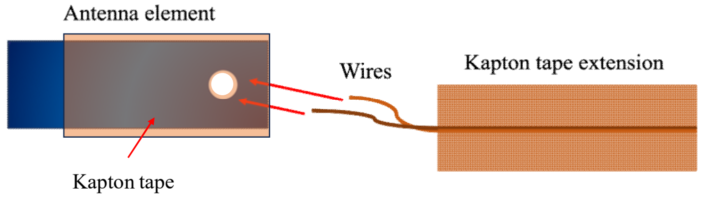


Figure 3.2.2-1 Stowed antenna configuration



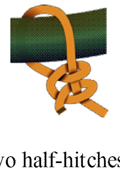


Figure 3.2.2-2 Connection between antenna element and Kapton tape extension (Step #1)

In Figure 3.2.2-2, Two half-hitches represent how the Kapton tape extension is secured to the deployment mechanism.

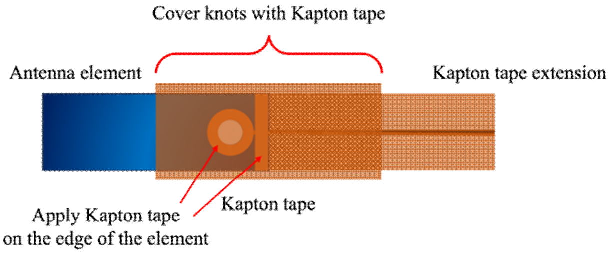


Figure 3.2.2-3 Connection between antenna element and Kapton tape extension (Step #2)

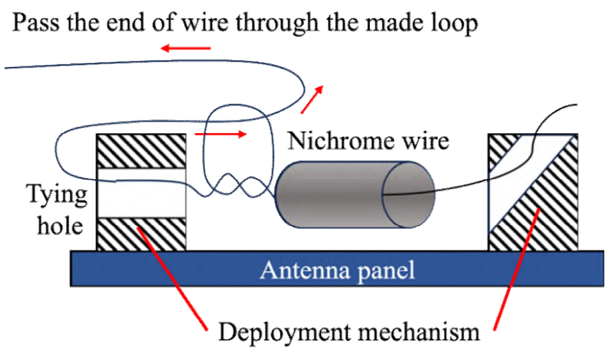


Figure 3.2.2-4 How to tie the wires

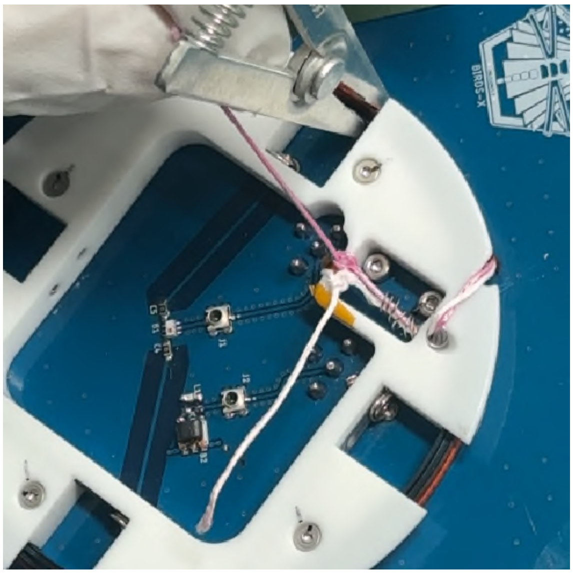


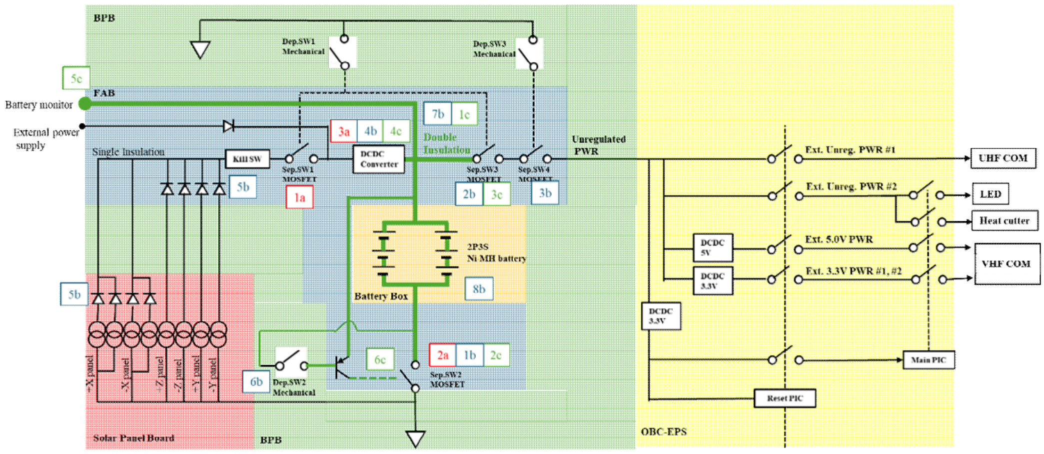
Figure 3.2.2-5 Locations where the wires are secured to the deployment mechanism

3.2.3 Electrical Power System

Electrical power system uses BIRDS-Bus. Inhibit control is based on BIRDS-Bus. Six Nickel Metal Hydride - NiOOH/metal alloy/KOH batteries are connected by three-series and two-parallel. The CubeSat does not use wet Electrolytic Capacitor in EPS. For ±X solar panels, a diode on the panel is used instead of a diode on the FAB to inhibit battery over-discharge.

DARGONFLY also has three deployment switches on the -Z rail ends whose specification and install/actuating position is shown in Table 3.2.3-1 and Figure 3.2.3-2, respectively.

Solar cell power analysis is performed to verify that OBC is not activated in JEM. (Refer to Appendix C-6.)



Hazard		Hazard Control #1	Hazard Control #2	Hazard Control #3
Over-charge		SepSW1[1a]	SepSW2[2a]	DCDC converter[3a]
Over-discharge	Load side	SepSW2[1b]	SepSW3[2b]	SepSW4[3b]
	Solar cell side		DCDC converter[4b]	Diode[5b]
	DepSW2 side	DepSW2 [9b]	Proper Insulation[7b]	Proper charging [8b]
External short	Load side	Proper Insulation[1c]	SepSW2[2c]	SepSW3[3c]
	Solar cell side			DCDC converter[4c]
	External power supply side			DCDC converter[4c]
	Battery monitor side			Proper Insulation[5c]
	DepSW2 side			Proper Insulation[6c]

Note: Proper insulation (double insulation) is shown by green line in the figure above and singe insulation in black line.
All wires and components between the battery and the first power functions are assembled as double insulation.
The DCDC converter (LT3119) used for inhibit is a buck-boost converter and its internal FET configuration prevents reverse current

Figure 3.2.3-1 Electrical Power System Schematic for hazard controls

Table 3.2.3-2 Deployment switch specification

Manufacture / Part No.	C&K inc. / DEP012
Rated current (A)	0.1
Rated Voltage (V)	12
Operating Temperature (℃)	-40 - +85
Releasing Force (N)	0.25*

* DRAGONFLY also has a spring plunger whose spring force is 0.6 N. Therefore the total spring force is 1.35 N, which meets Applicable Document (3).

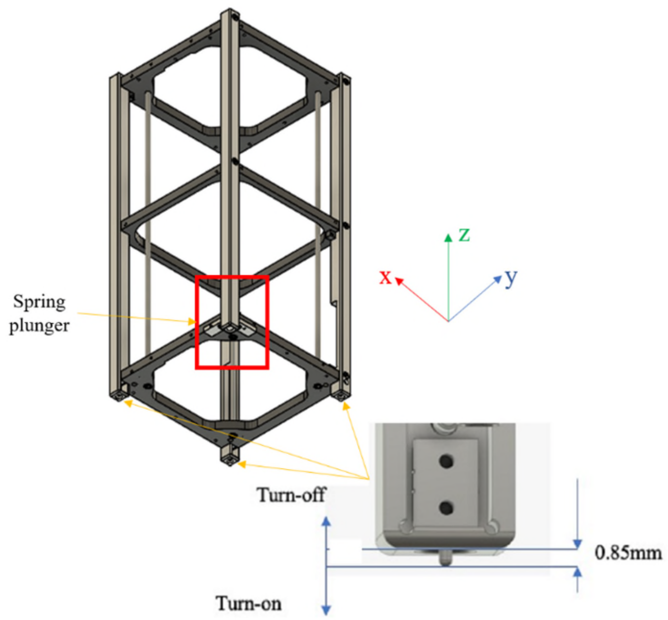


Figure 3.2.3-2 Deployment switch install and actuating position

3.2.4 Communication System

The Communication system transmits and receives UHF and VHF.

The UHF Communication system receives command uplink from the ground station and sends telemetry/housekeeping to the ground station. The UHF transmitter is the same as BIRDS-5 (437.375 MHz with max transmission power of 0.96 W).

The VHF Communication system receives data from the ground sensors and sends these data to the ground station. The VHF transmitter is the same as BIRDS-5 (145.825 MHz with max transmission power of 0.6 W).

The operating sequence after deployed from ISS is also the same as BIRDS-5 as shown below:

1) Deployment switches are closed.

2) OBC starts operation.

3) OBC waits for 2,000 seconds and confirms that batteries generate enough output voltage.

4) OBC activates the heater circuit connecting to nichrome wire for antenna deployment mechanism.

5) The heater circuit stops after antenna deployment.

6) The transceiver turns ON after antenna deployment and commands can be received. CW beacon is transmitted.

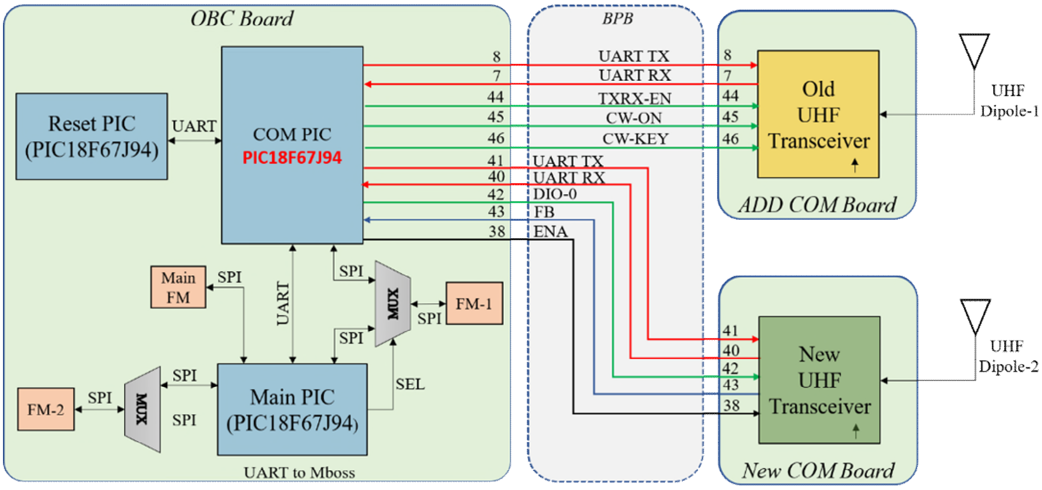


Figure 3.2.4-1 UHF Communication Subsystem Block Diagram

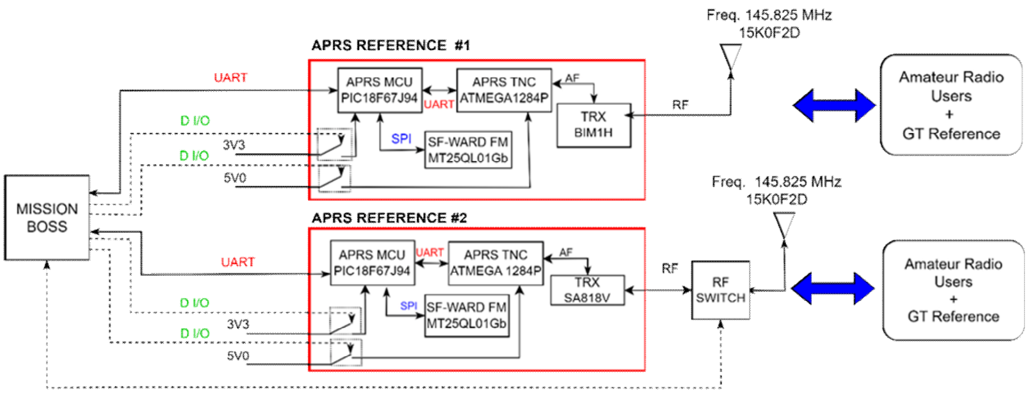


Figure 3.2.4-2 VHF Communication Subsystem Block Diagram

3.2.5 Mission

3.2.5.1 LED

DRAGONFLY has 5 LEDs the +X solar panel. The LEDs serve to provide an indication and confirm that the satellite has turned on after antenna deployment by observation from the ISS. The location of the LEDs on the satellite can be found as shown in Figure 3.2.5.1-1. Table 3.2.5.1-1 shows the characteristics of the LEDs used.

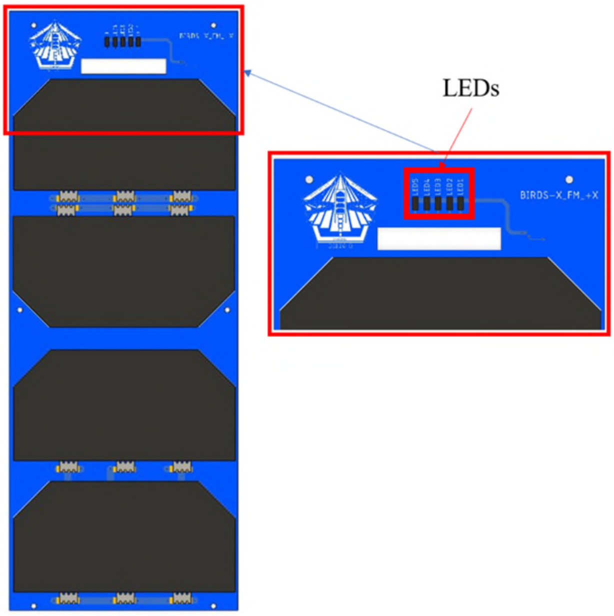


Figure 3.2.5.1-1 Communication Subsystem Block Diagram

Table 3.2.5.1-1 LED Properties

Parts Number	APTD1608URCK
Manufacturer	Kingbright
Wavelength at Peak Emission IF = 20mA	645nm
Operating/Storage Temperature	-40°C to +85°C
Luminosity lv	800 mcd

The results of the brightness analysis of the LEDs used are shown below.

Isotropic light source, the luminous flux Φ_v in lumens (lm) is equal to the luminosity I_v in millicandela (mcd), times the solid angle Ω in steradians (sr) divided by 1000:

$$\Phi_{v(lm)} = I_{v(mcd)} \times \Omega_{(sr)}/1000$$

The solid angle Ω in steradians (sr) is equal to 2 times π times 1 minus cosine of half the apex angle θ in degrees (°):

$$\Omega_{(sr)} = 2\pi\left(1 - \cos\left(\frac{\theta}{2}\right)\right)$$

The luminous flux Φ_v in lumens (lm) is equal to the luminosity I_v in millicandela (mcd), times 2 times π times 1 minus cosine of half the apex angle θ in degrees (°) divided by 1000:

$$\Phi_{v(lm)} = I_{v(mcd)} \times \frac{\left(2\pi\left(1-\cos\left(\frac{\theta}{2}\right)\right)\right)}{1000}$$

Luminosity of the LED used is 800 mcd and the apex angle is 60°. The error of luminosity is 15%. Therefore, the maximum luminosity is 920 mcd.

So, luminous flux is

$$\Phi_{v(lm)} = 920 \times \frac{\left(2\pi\left(1-\cos\left(\frac{60}{2}\right)\right)\right)}{1000} = 0.7744\ [lm]$$

To convert Lumens to Nits divide the number of Lumens by 3.426. Luminance of the LED used is 0.226 nits. Since 5 LEDs are used, if these lights overlap, the maximum luminance is 1.130 nits. This value is very small compared to the required 10,000nits, and the LED is not a hazard item.

4 Launch Configuration and Operation

Launch configuration and operation until DRAGONFLY is deployed from ISS is the same as Applicable Document (2).

5 Hazard Analysis Result

5.1 Hazard Identification and Assessment

There is no new identified hazard. DRAGONFLY has no high-voltage (>32 V) circuit, Electrical Shock (BIRDS5-UNQ-05) is not applicable to DRAGONFLY hazard analysis. All the other hazards based on Applicable Document (2) are applicable to DRAGONFLY.

The difference of assessment from HR in Applicable Document (2) is the followings:

- No need for the camera lens and filter assessment in the verification of BIRDS5-UNQ-01, since the satellite does not use a camera,
- No need for magnetic field assessment in the verification of STD-12, because the satellite does not use the magnet and the magnetic torquer,

The hazard controls and verification method in Applicable Document (2) can be applied to DRAGONFLY, except for HR described in section 5.2. The verification result is shown in Appendix B-1 “Baseline Hazard Report Verification Matrix”.

5.2 Modification of Hazard Report

The satellite is equipped with a +X solar panel with 5 LEDs. IVA Crew Exposure to Light Amplification by Stimulated Emission of Radiation (LASER) and/or Incoherent Electromagnetic Radiation Emissions evaluated according to the Standard Hazard approach. Refer to Appendix B-3, SHR-7.

The Unique Hazard Report for Impact / Collision to ISS due to inappropriate CubeSat deployment from J-SSOD by inadvertently deployment (BIRDS5-UNQ-04) need to be modified because the deployable antenna design is changed. Refer to Appendix B-2"BIRDSX-UNQ-04".

Appendix A. Abbreviation and Acronyms

COTS	Commercial Off-The-shelf
FEA	Finite Element Analysis
FEM	Finite Element Method
FS	Factor of Safety
ISS	International Space Station
J-SSOD	JEM Small Satellite Orbital Deployer
JEM	Japanese Experiment Module
MIUL	Materials Identification Usage List
MS	Margin of Safety
MUA	Material Usage Agreement
NASA	National Aeronautics and Space Administration
SAR	Safety Assessment Report
COM	Communicator
JAXA	Japan Aerospace Exploration Agency
MCU	Micro Control Unit
MS	Margins of Safety
MUA	Material Usage Agreement
NDE	Non-destructive Evaluation
PIC	Peripheral Interface Controller

Appendix B-1. Baseline Hazard Report Verification Matrix

Appendix B-1. Baseline Hazard Report Verification Matrix

No.	Hazard Title	Verification No.	Verification Document	Status	Note
SHR-1	Flammable Material	V-1.1(a)	**MIUL** BIRDSX-MIUL-01	Closed (January 10, 2024)	
SHR-2	Material Offgassing	V-2(a)	**MIUL** BIRDSX-MIUL-01	Closed (January 10, 2024)	
SHR-3	Inadvertent Release of Battery Electrolyte	V-3(b)	**HMST** Appendix C-3 Common Battery HMST	Closed (January 10, 2024)	
SHR-5	A Crew Exposure to Mechanical Hazards	V-5.1(a)	設計図面 BIRDSX-AD-01	Closed (January 26, 2024)	
		V-5.1(b)	シャープエッジ検査記録 BIRDSX-SEIR-01	To be closed at Phase III	
SHR-10	Injury/Damage as a Result of Improper Power Distribution Circuitry and Circuit Protection Devices	V-10.1(a)	**JAXA** チェックリストに従った評価 Appendix C-7 (BIRDSX-STD-Attachment-1)	<For phase 0/I/II> Closed (March 23, 2024) <For phase III> To be closed at Phase III	

No.	Hazard Title	Verification No.	Verification Document	Status	Note
			JAXA チェックリストに従った評価 BIRDSX-VTL-01	Closed to VTL	
		V-10.1(b)	ワイヤディレーティング評価(解析) Appendix C-8 (BIRDSX-STD-Attachment-2)	Closed (April 10, 2024)	
		V-10.1(c)	ワイヤディレーティング評価(検査) BIRDSX-STD-Attachment-3	To be closed at Phase III	
SHR-12	Non-Ionizing Radiation Interference	V-12.1	電磁放射、感受性評価 BIRDSX-STD-Attachment-4	Closed (March 22, 2024)	DRAGONFLY has no permanent magnet. Therefore, verification is needed just for FET susceptibility.

No.	Hazard Title	Verification No.	Verification Document	Status	Note
		V-12.2	**小型衛星共通の試験不要となる TIA** Appendix C-4 (TIA#1416A)	Closed (May 30, 2014)	
		V-12.4	**OE-14-002 適合性評価** BIRDSX-STD-Attachment-5	Closed (January 28, 2024)	
			SSP50005 適合性評価 (SRAG 評価シート) Appendix C-5 (Hazard Analysis Verification Space Radiation Analysis Group (SRAG))	Closed (January 29, 2024)	
BIRDS5-UNQ-01	Structure Failure	1.1-1(1)	**梱包検査(SVTL)** BIRDSX-VTL-01	Closed to VTL	
		1.1-1(2)	**質量確認** BIRDSX-IVR-01	To be closed at Phase III	

No.	Hazard Title	Verification No.	Verification Document	Status	Note
		1.1-2	構造解析書 BIRDSX-SR-01	Closed (May 28, 2024)	
		1.2	**MIUL** BIRDSX-MIUL-01	Closed (January 10, 2024)	
		1.3	構造フラクチャコントロール評価フォーム BIRDSX-FCE-01	Closed (June 17, 2024)	
			構造フラクチャコントロール評価フォーム BIRDSX-FCE-02	To be closed at Phase III	
		1.4(1)	構造フラクチャコントロール評価フォーム BIRDSX-FCE-01	Closed (June 17, 2024)	

No.	Hazard Title	Verification No.	Verification Document	Status	Note
			構造フラクチャコントロール評価フォーム BIRDSX-FCE-02	To be closed at Phase III	
		1.4(2)	振動試験報告書 BIRDSX-VT-01	To be closed at Phase III	
		1.5(1)	組立手順 BIRDSX-AP-01	Closed (June 7, 2024)	
		1.5(2)	組立記録 BIRDSX-AR-01	To be closed at Phase III	
		1.5(3)	振動試験報告書 BIRDSX-VT-01	To be closed at Phase III	
		1.6(1)	設計図面 BIRDSX-AD-01	Closed (January 26, 2024)	

No.	Hazard Title	Verification No.	Verification Document	Status	Note
		1.6(2)	組立記録 BIRDSX-AR-01	To be closed at Phase III	
		2.1.2	振動試験報告書 BIRDSX-VT-01	To be closed at Phase III	The verification target is 16 solar cells.
BIRDS5-UNQ-02	Battery Leakage / Rupture	1.1(1) 1.1(2) 1.1(3) 1.1(4) 1.2-1 1.2-2(1) 1.2-2(2) 1.3(1) 1.3(2) 1.4-1(1) 1.4-1(2) 1.4-1(3) 1.4-2(1) 1.4-2(2) 1.5	・回路設計 BIRDSX-EP-01	Closed (March 22, 2024)	Modify the verification method to change the blocking diode used for inhibit.
			・バッテリ検証試験 BIRDSX-BVR-01	To be closed at Phase III	
			・絶縁検査 ・保護装置機能試験 BIRDSX-IFTR-01	To be closed at Phase III	
			・リーク電流解析 Appendix C-10 (Leakage current evaluation)	Closed (March 22, 2024)	
			・引渡し前充電量確認 ・絶縁検査 BIRDSX-VTL-01	Closed to VTL	

No.	Hazard Title	Verification No.	Verification Document	Status	Note
BIRDS5-UNQ-03	Exposure of the ISS to Excessive Levels of EMI radiation and RF radiation	1.1	インヒビット機能試験 BIRDSX-IFTR-01	To be closed at Phase III	The UHF communication system meets the criteria in SSP30237 and SSP50005 and is assessed in STD-12. The VHF communication system meets the criteria in SSP50005, do not meets the criteria in SSP30237 and is assessed in UNQ-03.
BIRDS5-UNQ-04	Impact / Collision to ISS due to inappropriate CubeSat deployment from J-SSOD by inadvertently-deployment	1.1-1(1)	インヒビット機能試験 BIRDSX-IFTR-01	To be closed at Phase III	
		1.1-1(2)	絶縁検査 BIRDSX-IFTR-01	To be closed at Phase III	
		1.1-2	構造フラクチャコントロール評価フォーム BIRDSX-FCE-01	Closed (June 17, 2024)	

No.	Hazard Title	Verification No.	Verification Document	Status	Note
			構造フラクチャコントロール評価フォーム BIRDSX-FCE-02	To be closed at Phase III	
		1.2	設計図面 BIRDSX-AD-01	Closed (January 26, 2024)	
			組立記録 BIRDSX-AR-01	To be closed at Phase III	
BIRDS5-UNQ-05	Electrical Shock	1.1-1 1.1-2 1.1-3	N/A	N/A	DRAGONFLY has no high voltage system.

Signature (Effective for this "Baseline Hazard Report Verification Matrix")		
APPROVAL	HARDWARE ORGANIZATION (Printed Name, Signature, Date)	ISS SAFETY REVIEW PANEL (ISRP) (Printed Name, Signature, Date)
Phase 0/I		
Phase II	Etsunaga Yudai, 2024/07/25	KOBAYASHI Ryoji 小林亮二 Jul. 30, 2024
Phase III		

Appendix B-2. Unique Hazard Report

5 項で識別されたユニークな **HR** を示す。**(**基本的には通常の **SAR** と同様、フォーム

ISS_OE_851 で添付すること。記載方法は **JSX-2009032**「安全評価報告書作成要領」参照。**)**

Appendix B-3. Standard Hazard Report

5 項で識別されたユニークな HR を示す。(基本的には通常の SAR と同様、フォーム

ISS_OE_851 で添付すること。記載方法は JSX-2009032「安全評価報告書作成要領」参照。)

7. IVA Crew Exposure to Light Amplification by Stimulated Emission of Radation (LASER) and/or Incoherent Electromagnetic Radiation Emissions					App.(STD only) : LASER Emissions Exposure N/A(STD and UNQ) : Incoherent Light Emissions Exposure
Hazard Description: Crew exposure to high-intensity LASER and/or incoherent electromagnetic radiation emissions may result in biological damage to the eye or skin. Sustained damage to the eye is a common effect of exposure leading to crew incapacitation or blindness. Skin tissue destruction can also occur.					
[UNQ HRが必要な条件]Transfer to UNQ HR：Class 1M, 2M, 3R, 3B and 4 Laser or Incoherent Electromagnetic Radiation Emissions for over 10,000 nits					
[選択必須] (For laser)	**Ctl-7.1：LASER Emissions Exposure** The crew will not be exposed to high-intensity LASER emissions. Select of Verifications: (Optional) Use Class 1 Laser = (a) (Optional) Use Class 2 Laser = (b) [Note] If apply some verifications, Refer to Attachment for Applicated items Summary, which identify for items, each class, activation Phase(operation task)		**V-7.1(a)**	**Class 1 LASER**	
			Analysis Verify Once	An assessment has been performed to ensure the LASER design is not capable of emitting in excess of the Class 1 Accessible Emission Limit (AEL), which varies by wavelength and pulse duration, OR For COTS hardware only, the LASER (COTS hardware labeled as Class 1, but unable to confirm LASER strength) is enclosed via means of describe containment and features of the system to preclude crew exposure to the LASER emissions, which prohibits or limits access to the LASER radiation.	
			Status	**Completion Date**	**Closure Documentation**
			and/or		
			V-7.1(b)	**Class 2 LASER**	
			Analysis Verify Once	An assessment has been performed to ensure that: (a) the LASER design Continuous Wave (CW) and repetitive-pulse LASERs emissions are in the visible region of the spectrum (0.4 to 0.7 μm), and (b) the LASERs can emit accessible radiant energy exceeding the Class 1 AEL for the maximum duration inherent in the LASER, but not exceeding the Class 1 AEL for any pulse duration < 0.25 s (the time estimated to blink or look away), and (c) not exceeding an average radiant power of 1 mW. OR For COTS hardware only, the LASER (COTS hardware labeled as Class 2, but unable to confirm LASER strength) is enclosed via means of describe containment and features of the system to preclude crew exposure to the LASER emissions, which prohibits or limits access to the LASER radiation.	
			Status	**Completion Date**	**Closure Documentation**
[選択必須] (For Incoherent Electromagnetic Radiation)	**Ctl-7.2：Incoherent Electromagnetic Radiation Emissions Exposure** The crew will not be exposed to incoherent electromagnetic radiation emissions.	√	**V-7.2**	**Low Intensity Design**	
			Analysis Verify Once	An assessment has been performed to ensure the Incoherent Electromagnetic Radiation design is not capable of emitting in excess of 10,000 nits (nits=cd/m^2) to confirm the design is a marginal hazard.	
			Status	**Completion Date**	**Closure Documentation**
			Closed	22-Mar-24	BIRDSX-SAR-01 Section 3.2.5.1

HR #: BIRDSX-STD-01	**System/Payload: Payload**
Item Name: DRAGONFLY	**Status: -**
Phase: Phase 0/I/II	**Revision Date: 03/22/2024**
Flight Applicability: HTV-X, Cygnus or Dragon	**Report POC: Yudai Etsunaga**
Interfaces:No direct interface with ISS, only with Deployer(J-SSOD) which interfaces with JEM Airlock and JEMRMS	
Hardware *Name (include part number(s))*	
Satellite Name: DRAGONFLY **P/N: DRAGONFLY-FM-01**	

APPROVAL	HARDWARE ORGANIZATION Printed Name, Signature, Date	ISS SAFETY REVIEW PANEL (ISRP) Printed Name, Signature, Date
Phase I	N/A	N/A
Phase II	Etsunaga Yudai , 2024/07/25	KOBAYASHI Ryoji 小林亮二 Jul. 30, 2024
Phase III	-	-

Signatures about are effective for all the following pages.

SPECIFICATIONS (T_J = 25 °C, unless otherwise noted)						
PARAMETER	**SYMBOL**	**TEST CONDITIONS**	**MIN.**	**TYP.**	**MAX.**	**UNIT**
Static						
Drain-source breakdown voltage	V_{DS}	V_{GS} = 0, I_D = -250 μA	-12	-	-	V
V_{DS} temperature coefficient	$\Delta V_{DS}/T_J$	I_D = -250 μA	-	-7	-	mV/°C
$V_{GS(th)}$ temperature coefficient	$\Delta V_{GS(th)}/T_J$		-	3	-	
Gate-source threshold voltage	$V_{GS(th)}$	V_{DS} = V_{GS}, I_D = -250 μA	-0.4	-	-0.85	V
Gate-source leakage	I_{GSS}	V_{DS} = 0 V, V_{GS} = ± 8 V	-	-	± 100	nA
Zero gate voltage drain current	I_{DSS}	V_{DS} = -12 V, V_{GS} = 0 V	-	-	-1	μA
		V_{DS} = -12 V, V_{GS} = 0 V, T_J = 55 °C	-	-	-10	
On-state drain current [a]	$I_{D(on)}$	$V_{DS} \leq$ -5 V, V_{GS} = -4.5 V	-10	-	-	A
Drain-source on-state resistance [a]	$R_{DS(on)}$	V_{GS} = -4.5 V, I_D = -7 A	-	0.0110	0.0135	Ω
		V_{GS} = -2.5 V, I_D = -5 A	-	0.0150	0.0194	
		V_{GS} = -1.8 V, I_D = -3 A	-	0.0230	0.0344	
		V_{GS} = -1.5 V, I_D = -1 A	-	0.0400	0.0710	
Forward transconductance [a]	g_{fs}	V_{DS} = -6 V, I_D = -7 A	-	35	-	S
Dynamic [b]						
Input capacitance	C_{iss}	V_{DS} = -6 V, V_{GS} = 0 V, f = 1 MHz	-	2880	-	pF
Output capacitance	C_{oss}		-	590	-	
Reverse transfer capacitance	C_{rss}		-	585	-	
Total gate charge	Q_g	V_{DS} = -6 V, V_{GS} = -8 V, I_D = -13 A	-	52	80	nC
		V_{DS} = -6 V, V_{GS} = -4.5 V, I_D = -13 A	-	31	47	
Gate-source charge	Q_{gs}		-	4.2	-	
Gate-drain charge	Q_{gd}		-	7.8	-	
Gate resistance	R_g	f = 1 MHz	0.8	4.3	8.6	Ω
Turn-on delay time	$t_{d(on)}$	V_{DD} = -6 V, R_L = 0.6 Ω $I_D \cong$ -10 A, V_{GEN} = -4.5 V, R_g = 1 Ω	-	30	60	ns
Rise time	t_r		-	30	60	
Turn-off delay time	$t_{d(off)}$		-	60	120	
Fall time	t_f		-	25	50	
Turn-on delay time	$t_{d(on)}$	V_{DD} = -6 V, R_L = 0.6 Ω $I_D \cong$ -10 A, V_{GEN} = -8 V, R_g = 1 Ω	-	12	25	
Rise time	t_r		-	10	20	
Turn-off delay time	$t_{d(off)}$		-	65	130	
Fall time	t_f		-	20	40	
Drain-Source Body Diode Characteristics						
Continuous source-drain diode current	I_S	T_C = 25 °C	-	-	-12	A
Pulse diode forward current	I_{SM}		-	-	-50	
Body diode voltage	V_{SD}	I_S = -10 A, V_{GS} = 0 V	-	-0.8	-1.2	V
Body diode reverse recovery time	t_{rr}	I_F = -10 A, di/dt = 100 A/μs, T_J = 25 °C	-	25	50	ns
Body diode reverse recovery charge	Q_{rr}		-	7.5	15	nC
Reverse recovery fall time	t_a		-	8	-	ns
Reverse recovery rise time	t_b		-	17	-	

Notes

a. Pulse test; pulse width ≤ 300 μs, duty cycle ≤ 2%

b. Guaranteed by design, not subject to production testing

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability

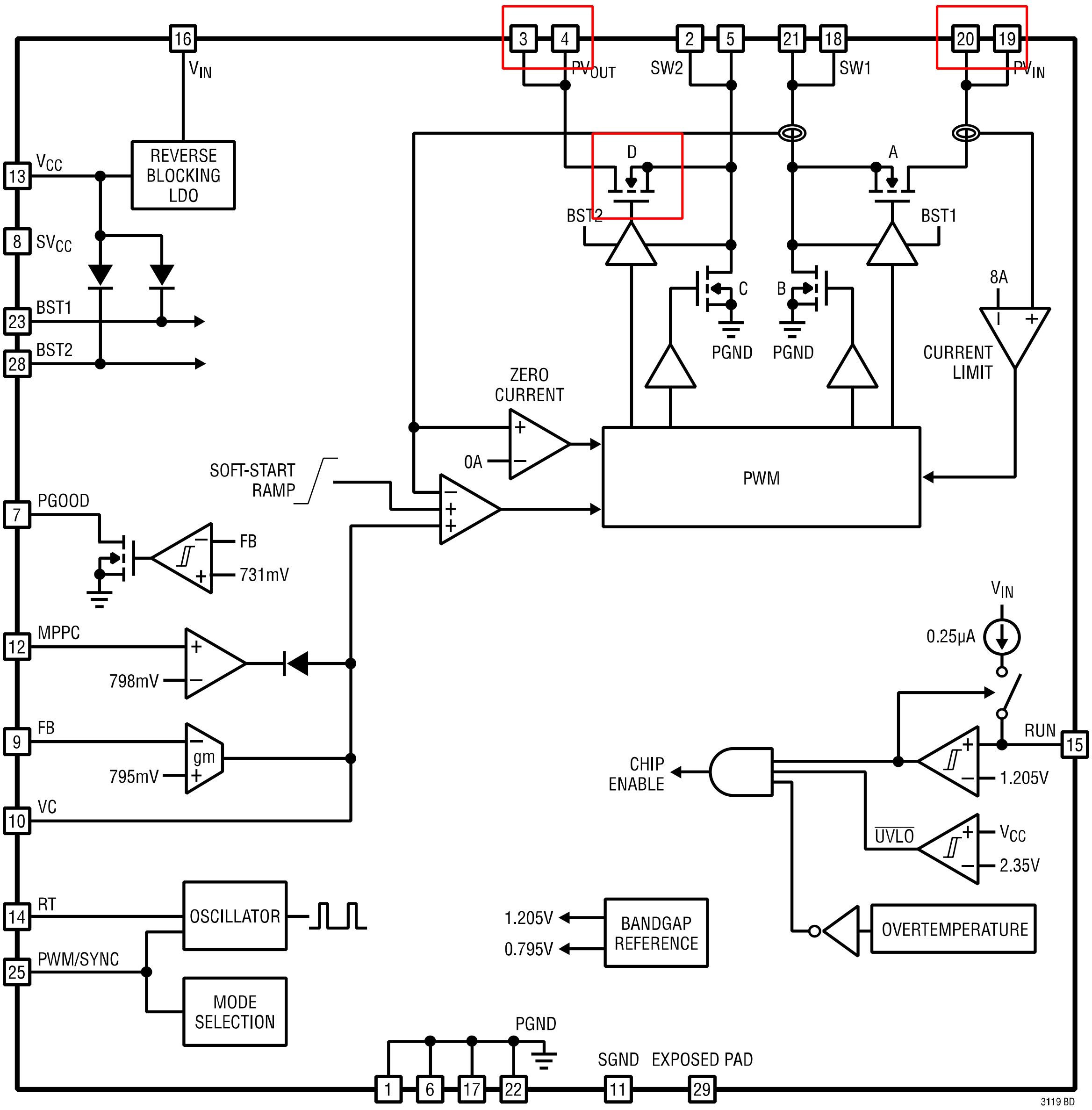
SPECIFICATIONS (T_J = 25 °C, unless otherwise noted)						
PARAMETER	**SYMBOL**	**TEST CONDITIONS**	**MIN.**	**TYP.**	**MAX.**	**UNIT**
Static						
Drain-Source Breakdown Voltage	V_{DS}	V_{GS} = 0 V, I_D = 250 µA	20	-	-	V
V_{DS} Temperature Coefficient	$\Delta V_{DS}/T_J$	I_D = 250 µA	-	22	-	mV/°C
$V_{GS(th)}$ Temperature Coefficient	$\Delta V_{GS(th)}/T_J$		-	-3	-	
Gate-Source Threshold Voltage	$V_{GS(th)}$	$V_{DS} = V_{GS}$, I_D = 250 µA	0.4	-	1	V
Gate-Source Leakage	I_{GSS}	V_{DS} = 0 V, V_{GS} = ± 8 V	-	-	± 100	nA
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS} = 20 V, V_{GS} = 0 V	-	-	1	µA
		V_{DS} = 20 V, V_{GS} = 0 V, T_J = 55 °C	-	-	10	
On-State Drain Current [a]	$I_{D(on)}$	$V_{DS} \geq$ 5 V, V_{GS} = 10 V	20	-	-	A
Drain-Source On-State Resistance [a]	$R_{DS(on)}$	V_{GS} = 4.5 V, I_D = 10 A	-	0.0135	0.0164	Ω
		V_{GS} = 2.5 V, I_D = 9 A	-	0.0160	0.0200	
		V_{GS} = 1.8 V, I_D = 8.2 A	-	0.0190	0.0240	
Forward Transconductance [a]	g_{fs}	V_{DS} = 10 V, I_D = 10 A	-	47	-	S
Dynamic [b]						
Input Capacitance	C_{iss}	V_{DS} = 10 V, V_{GS} = 0 V, f = 1 MHz	-	1220	-	pF
Output Capacitance	C_{oss}		-	180	-	
Reverse Transfer Capacitance	C_{rss}		-	80	-	
Total Gate Charge	Q_g	V_{DS} = 15 V, V_{GS} = 8 V, I_D = 10 A	-	21	32	nC
		V_{DS} = 15 V, V_{GS} = 4.5 V, I_D = 10 A	-	12	18	
Gate-Source Charge	Q_{gs}		-	2	-	
Gate-Drain Charge	Q_{gd}		-	1.3	-	
Gate Resistance	R_g	f = 1 MHz	-	1.8	3.6	Ω
Turn-On Delay Time	$t_{d(on)}$	V_{DD} = 10 V, R_L = 1.25 Ω $I_D \cong$ 8 A, V_{GEN} = 4.5 V, R_g = 1 Ω	-	10	15	ns
Rise Time	t_r		-	10	15	
Turn-Off Delay Time	$t_{d(off)}$		-	35	55	
Fall Time	t_f		-	10	15	
Turn-On Delay Time	$t_{d(on)}$	V_{DD} = 10 V, R_L = 1.25 Ω $I_D \cong$ 8 A, V_{GEN} = 8 V, R_g = 1 Ω	-	10	15	
Rise Time	t_r		-	10	15	
Turn-Off Delay Time	$t_{d(off)}$		-	25	40	
Fall Time	t_f		-	10	15	
Drain-Source Body Diode Characteristics						
Continuous Source-Drain Diode Current	I_S	T_C = 25 °C	-	-	19	A
Pulse Diode Forward Current	I_{SM}		-	-	40	
Body Diode Voltage	V_{SD}	I_S = 8 A, V_{GS} = 0 V	-	0.81	1.2	V
Body Diode Reverse Recovery Time	t_{rr}	I_F = 8 A, dI/dt = 100 A/µs, T_J = 25 °C	-	20	30	ns
Body Diode Reverse Recovery Charge	Q_{rr}		-	15	25	nC
Reverse Recovery Fall Time	t_a		-	12.5	-	ns
Reverse Recovery Rise Time	t_b		-	7.5	-	

Notes

a. Pulse test; pulse width ≤ 300 µs, duty cycle ≤ 2 %

b. Guaranteed by design, not subject to production testing.

Battery side Solar cell side



Block Diagram of DCDC convertor

OE-14-002 evaluation

Table 6.3-3 RF radiation

Freq. [MHz]	Transmit Power [W] (*2)	Antenna Gain [dBi]	Max. Radiation Power [W]	Electrical Field Strength [V/m] (*1)	Criteria (*3) Electrical Field Strength [V/m] (*1)
145.825	0.6	2	0.95	5.34	1.58
437.375	0.96	0.5	1.08	5.68	19

(*1) at 1[m] away from the source.

(*2) Transmitter capable max output.

(*3) OE-14-002.

Appendix C-1 Structure Fracture Control Evaluation Form

Structure Fracture Control Evaluation Form for Small Satellite deployed from J-SSOD

Satellite Name : DRAGONFLY【Phase 0/1/2】 JAXA Structure and Fracture Control Board (JAXA SFCB) Form Ver. June 17, 2024

	Signature	DATE
JAXA SFCB Chair	和田　勝 /WADA Masaru	18-Jun-24
Satellite Project Manager	JorgeRubenCasirRicano	2024/6/17

If all of condition A) to G) are fulfilled or approved waiver, this form can be applicable instead of Fracture Control Summary Report.
If any of condition H) to M) are applicable, correspondent verifications must be implemented.

Check	Title	Condition	Verification Document
☑	**A) Soft Stowed Launch**	Launched with stowed in softbag.	[Phase 012] Closed, Document No. :09_BIRDSX-SAR-01 Section4 Safety Assessment Report for Phase012 (2024/6/17) [Phase 3] Open, Document No. :16_BIRDSX-SAR-02 Safety Assessment Report for Phase3 (To be closed at Ph3)
☑	**B) Mass**	Less than 1.33kg per 1U.	[Phase 3] Open, J-SSOD&BIRDS-X Interface Verification Record Document No. : 19_BIRDSX-IVR-01(To be closed at Ph3)
☑	**C) Neither Pressure System nor Pressure Vessel**	With neither Pressure System nor Pressure Vessel	[Phase 012] Closed, Document No. :09_BIRDSX-SAR-01 Section5 Safety Assessment Report for Phase012 (2024/6/17) [Phase 3] Open, Document No. :16_BIRDSX-SAR-02 Safety Assessment Report for Phase3 (To be closed at Ph3)
☑	**D) No Hazardous Materials**	No toxic or biological material except for electrolyte of battery.	[Phase 012] Closed, Document No. :09_BIRDSX-SAR-01 Section5 Safety Assessment Report for Phase012 (2024/6/17) [Phase 3] Open, Document No. :16_BIRDSX-SAR-02 Safety Assessment Report for Phase3 (To be closed at Ph3)
☑	**E) Minimum Stress History**	H/W is not exposed to the stress environment other than the followings: 1) Random vibration test 2) Ground Transportation 3) Launch(1 time)	[Phase 012] Closed, Document No. :09_BIRDSX-SAR-01 Section5 Safety Assessment Report for Phase012 (2024/6/17) [Phase 3] Open, Document No. :16_BIRDSX-SAR-02 Safety Assessment Report for Phase3 (To be closed at Ph3)
-	**F) Low Risk Fracture Part**	Outer structure meets the following criteria:(as Low Risk Fracture Part)	—
☑	F-1) Maximum Stress	Total tensile stresses are no greater than 30% of ultimate tensile strength	[Phase012] Closed, Document No. :02_BIRDSX-SR-01 Section5.5.2 Structural Analysis Report (2024/5/28)
☑	F-2) Material	Aluminum alloy and A-rated in MSFC-HDBK-527/JSC09604/CR-99117 or Table-I in MSFC-STD-3029	[Phase012]Closed, Document No. :03_BIRDSX-MIUL-01 MIUL (2024/1/10)
☑	F-3) Material Processing	Not using a process such as welding, forging, casting, or quenching heat treatment	[Phase012] Closed, Document No. :02_BIRDSX-SAR-01 Section3.2.1 Safety Assessment Report for Phase012 (2024/6/17)
☑	F-4) Visual Inspection	No defects or surface damage is detected by visual inspection	[Phase3] Open, Document No. :25_BIRDSX-VT-01 Vibration Test Report (To be closed at Ph3)
☑	**G) No Delta Pressure Hazard**	No hazard is identified regarding the delta-pressure during launch, pressurization/ depressurization in airlock.	[Phase 012] Closed, Document No. :09_BIRDSX-SR-01 Section5.3 Structural Analysis Report(2024/5/28)

If the satellite consists of the following items, applicable section (H) to N)) should be fulfilled.

☑applicable	**H) Shatterable Structure**	**Shatterable Structure (Camera Lens, Solar Cell Cover etc.)**	—
☑	H-1) Vibration Test	1. Verified by visual inspection after vibration test under the condition specified in JX-ESPC-101132/101133	[Phase3] Open, Document No. :25_BIRDSX-VT-01 Vibration Test Report (To be closed at Ph3)
☑applicable	**J) Deployment Structure**	**Deployment restraint wire whose fracture could cause hazard.**	
☑	J-1) Fail Safe Approach	Redundant wire	[Phase 012] Closed, Document No. :06_BIRDSX-AP-01Section4.3, 4.4 Assembly Procedure(2024/6/7) [Phase 3] Open, Document No. :18_BIRDSX-AR-01 Assembly Record (To be closed at Ph3)
☑	J-2) Proof Test	Each wire is proof-tested and visual-inspected	[Phase 3] Open, Document No. :27_BIRDSX-WTR-01 Wire Strength Test Report (To be closed at Ph3)
☑	J-3) Assembly Procedure	Wire handling process is defined in assembly procedure.	[Phase 012] Closed, Document No. :06_BIRDSX-AP-01 Section 4.3, 4.4 Assembly Procedure(2024/6/7) [Phase 3] Open, Document No. :18_BIRDSX-AR-01 Assembly Record (To be closed at Ph3)
☑	J-4) Round	(If any) The part touching the wire is rounded appropriately.	[Phase 012] Closed, Document No. :06_BIRDSX-AD-01(Page14-17) Assembly Procedure(2024/01/29) [Phase 3] Open, Document No. :18_BIRDSX-AR-01 Assembly Record (To be closed at Ph3)
☑	J-5) Loosening Prevention	(If any) Loose prevention is provided on the tied portion.	[Phase 012] Closed, Document No. :06_BIRDSX-AP-01 Section 4.4 Assembly Procedure(2024/6/7) [Phase 3] Open, Document No. :18_BIRDSX-AR-01 Assembly Record (To be closed at Ph3)
☑ applicable	**K) Fail Safe Fastener**	**Fail Safe Fastener**	—
☑	K-1) Fail Safe Analysis	K-1) Fail safety analysis shows MS >0. (F.S = 1.0)	[Phase012] Closed, Document No. :02_BIRDSX-SR-01 Section 5.5.3 Structural Analysis Report (2024/5/28)
☑	K-2) Quality Control	Quality Control meets the condition L-2) to L-5).	Please refer from L-2) to L-5).
☑applicable	**L) Safety Critical Fastener**	**Safety Critical Fastener**	—
☑	L-1-1) Secondary Locking Feature	L-1-1b) Locking compound of which the application process MUA is approved.	②Loctite263 [Phase 012] Closed, Document No. :06_BIRDSX-AP-01 Assembly Procedure(2024/6/7) [Phase 3] Open, Document No. :18_BIRDSX-AR-01 Assembly Record (To be closed at Ph3)
☑	L-2-1) Certificates for fastener materials	L-2-1) Certificates for fastener materials	[Phase 3] Open, Document No. :18_BIRDSX-AR-01 Assembly Record (To be closed at Ph3)
☑	L-3) Torque mark inspection	L-3) Torque mark inspection	[Phase 012] Closed, Document No. :06_BIRDSX-AP-01 Assembly Procedure(2024/6/7) [Phase 3] Open, Document No. :18_BIRDSX-AR-01 Assembly Record (To be closed at Ph3) [Phase3] Open, Document No. :25_BIRDSX-VT-01 Vibration Test Report (To be closed at Ph3)
☑	L-4) Fastening torque control	L-4) Fastening torque control	[Phase 012] Closed, Document No. :06_BIRDSX-AP-01 Section4.1.7 Assembly Procedure(2024/6/7) [Phase 3] Open, Document No. :18_BIRDSX-AR-01 Assembly Record (To be closed at Ph3)
☑	L-5) Fastener traceability	L-5) Fastener traceability	[Phase 012] Closed, Document No. :06_BIRDSX-AP-01 Section4.1.3 Assembly Procedure(2024/6/7) [Phase 3] Open, Document No. :18_BIRDSX-AR-01 Assembly Record (To be closed at Ph3)
☐applicable	**M) Sealed Container**	**Sealed Container**	
☐	M-1) Container characteristic	Single, Independent Container containing a non-hazardous substance.	
☐	M-2) Stored Energy	Contain less than 19,310 Joules(14,240 foot-pounds) of stored energy	
☐	M-3) Maximum delta pressure	Maximum delta pressure is less than 1.5atm(22psia, 1.5bars)	
☑applicable	**N) Fracture Critical Part**	**Fracture Critical Part**	
☑	N-1) Design Verification	Verified by Structural Analysis with appropriate mechanical properties	[Phase012] Closed, Document No. :02_BIRDSX-SR-01 Section 5.4 Structural Analysis Report (2024/5/28)
☑	N-2) Production Verification	Verified by appropriate material selection and production process	[Phase 3] Open, Document No. :18_BIRDSX-AR-01 Assembly Record (To be closed at Ph3)
☑	N-3) Product Verification	Verified by visual inspection after vibration test under the condition specified in JX-ESPC-101132/101133 Visual Inspection and NDE(Tapping test acceptable) before and after Tests	[Phase3] Open, Document No. :25_BIRDSX-VT-01 Vibration Test Report (To be closed at Ph3)

Appendix C-2 Battery Description Form

Battery Description HR Attachment

For the Phase 0/I Safety Data Package, provide the following information:

1a. Hardware Point-of-Contact: **(Name/Company/Phone/Fax/email)**	**1b.**	
Yudai Etsunaga	**Hardware Name:**	DRAGONFLY
Kyushu Institute of technology	**Hardware Part Number:**	DRAGONFLY-FM-01
+81-93-884-3229	**Hardware Acronym:**	DRAGONFLY
etsunaga.yudai294@mail.kyutech.jp	**Battery Name:**	Ni-MH Battery

2a. Hardware / Battery Managing Group, Company, or Agency:

Kyushu Institute of Technology

2b. Hardware and Battery Environmental Requirements:

Thermal Environment (max, min, operational and non-operational ranges):

+10 to +46 degC during launch (HTV, SpX, Cygnus envelope temperature),

-15 to +60 degC inside J-SSOD (When J-SSOD is outside the ISS)

[Note]: Battery specification: Storage: -20 to +50 degC

Since the battery thermal specification does not cover the thermal environment, we will confirm by thermal test.

Pressure Environment (EVA, IVA):

Both EVA and IVA environments. Maximum pressure during launch and inside the ISS is as follows. A pressure inside JEM Airlock at depressurization and outboard is 0 Pa.

Lunch vehicle and inside the ISS: 104.8 kPa.

Life (calendar/shelf, cycle/service):

Duration 3 years / Product warranty of storage is 5 years to keep more than 90% capacity from fully charged

3a. Battery and Hardware Description:

Is the battery pack (including all components) Commercial-off-the-shelf (COTS)? ☒Yes ☐ No

Function/Operating modes (continuous, pulse, intermittent, clock backup, memory, etc.):

No operation inside J-SSOD. Continuous operation after deployment.

Battery/Cell crew access on-orbit? ☐Yes ☒ No

<u>Short Description of Battery System</u>: (Number of batteries to be flown; details if multiple batteries are required to power Application, unique design information, etc.)

Battery pack is in-house. EPS and FAB are COTS.

[Battery pack]

Part Name: DRAGONFLY-Battery

Type: NiMH Battery

Part Number: DRAGONFLY-Battery-01

Specification: 14.4 Wh

Manufacturer: Kyushu Institute of Technology

[FAB]

Part Name: DRAGONFLY-FAB

Part Number: BIRDSX-FAB-01

Manufacturer: Sagami Tsushin

[EPS]

Part Name: DRAGONFLY-EPS/OBC

Part Number: BIRDSX-EPS/OBC-01

Manufacturer: Sagami Tsushin

3b. Cell Description:

Chemistry (If li-ion, what type: NMC, NCA, FePO4, etc.): Ni-MH

Cell size: 14.35 mm dia. x 50.4 mm

Manufacture and Model: Panasonic / BK-3MCC

Nominal OCV: 1.2 V **Maximum Voltage:** 1.6 V **Minimum Voltage:** 1.0 V

Rated Capacity: 2,000 mAh

Maximum Rated OEM Discharge Current: Nonpublic information

Maximum Recommended OEM Charge Current: 2,000 mA

Minimum and Maximum OEM Discharge Temperatures: 0 to +50 degC

Minimum and Maximum OEM Charge Temperatures: 0 to +40 degC

Minimum and Maximum Storage Temperatures: -20 to +40 degC

Date of Manufacture (Mo/Yr): 01/2023

3c. Battery Information: (9 V COTS batteries shall be considered as single units)

Quantity of total cells: 6

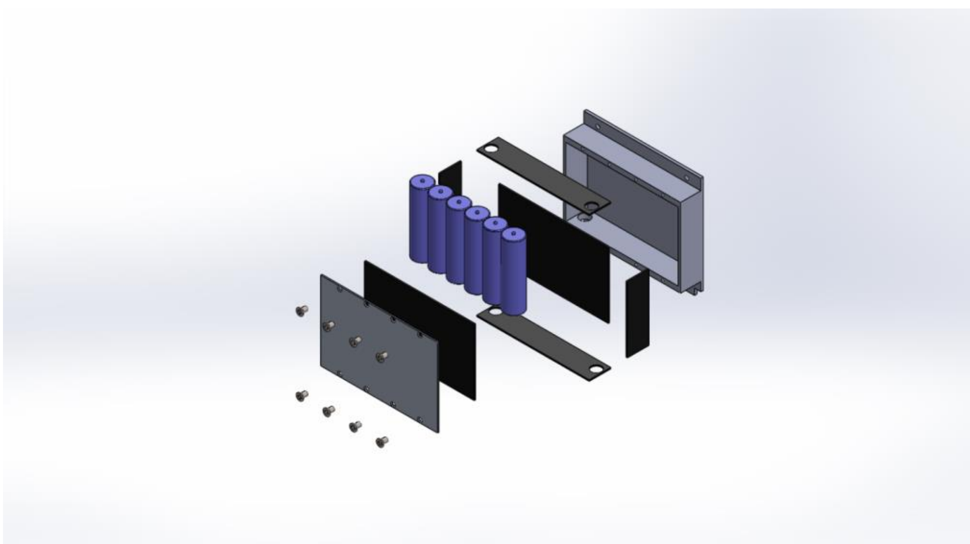
Cell connectivity (#P#S, #S#P): 3S2P

Operational Battery Environment Temperatures Range (Min/Max): 0 to +40 degC

Nominal OCV: 3.6 V **Maximum Voltage:** 4.8 V **Minimum Voltage:** 3.0 V

Battery Description HR Attachment

For the Phase II/III Safety Data Package, provide the following information:

Storage location (launch and on-orbit use locations):
Installed inside CubeSat. BIRDS-X (2U CubeSat) will be launched to ISS by HTV-X, Cygnus or SpX with being installed inside J-SSOD (JEM Small Satellite Orbital Deployer) satellite install case or a dedicated launch case, which is soft stowed inside a bag.
Packaging and hardware approved by flammability group (reference requirement):
1/10/2024 (MIUL)
Is the battery charged on orbit?, Yes: ☐ No: ☒   **If yes, describe charge rate, charger hardware, and protections to prevent overcharge**
Is the battery being discharged on-orbit? Yes: ☐ No: ☒ If yes what is the discharge rate(s):
Circuit Description and Electrical Schematic (attach electronically or reference location in HR):
All of the cells are covered by TEFLON panels and metal box same as BIRDS-1: EP-J-17-001 (Figure 1).      **Figure 1 Battery Box**

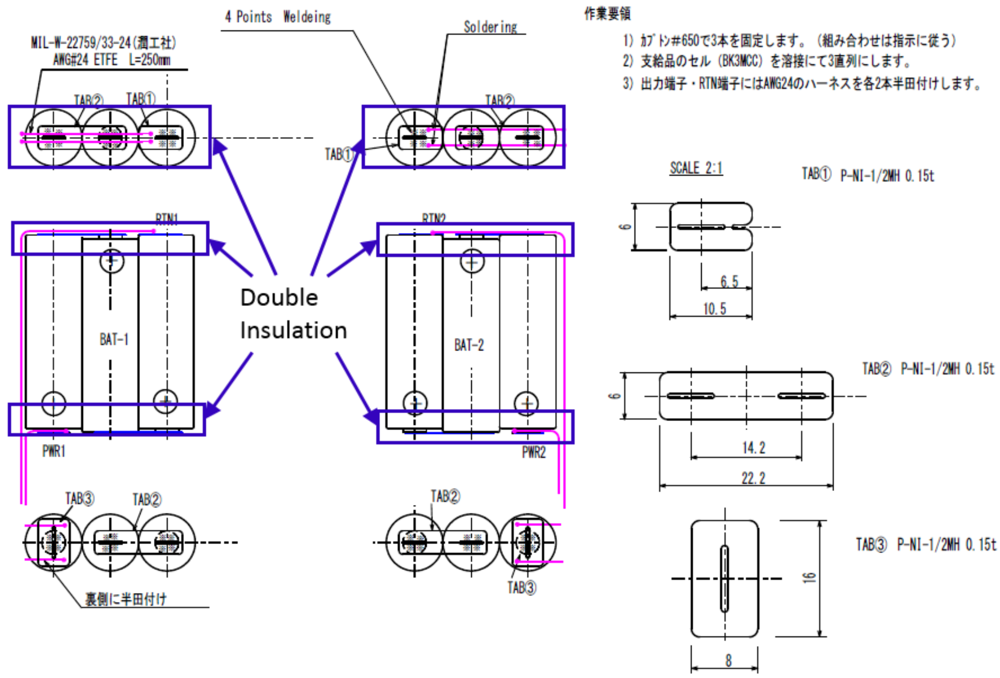
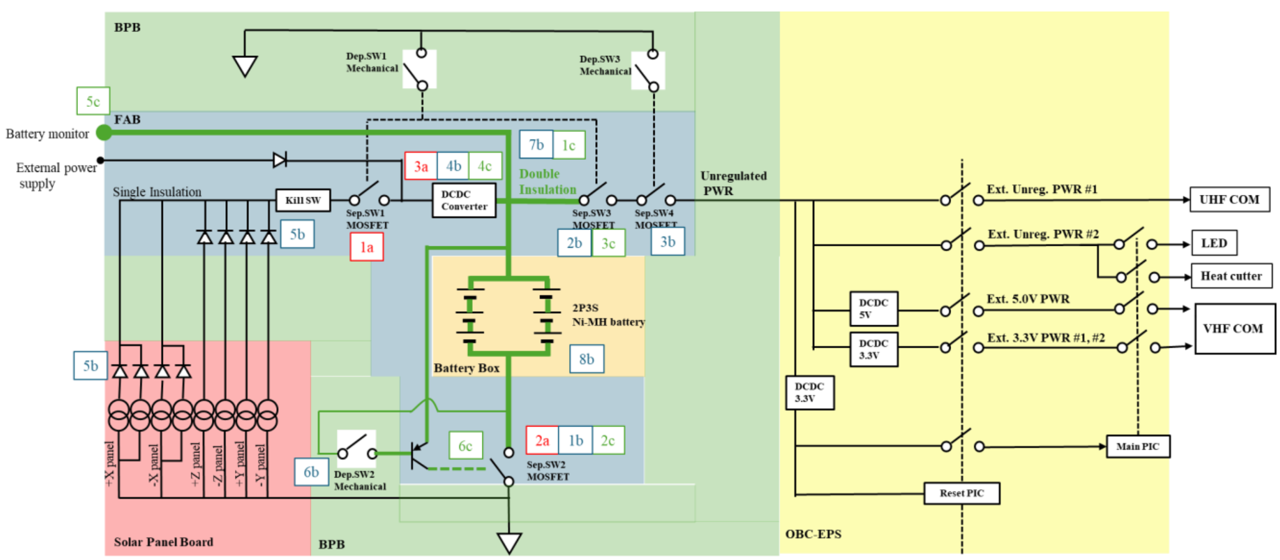


Figure 2 Battery Connectivity



Hazard		Hazard Control #1	Hazard Control #2	Hazard Control #3
Over-charge		SepSW1[1a]	SepSW2[2a]	DCDC converter[3a]
Over-discharge	Load side	SepSW2[1b]	SepSW3[2b]	SepSW4[3b]
	Solar cell side		DCDC converter[4b]	Diode[5b]
	DepSW2 side	DepSW2 [9b]	Proper Insulation[7b]	Proper charging [8b]
External short	Load side	Proper Insulation[1c]	SepSW2[2c]	SepSW3[3c]
	Solar cell side			DCDC converter[4c]
	External power supply side			DCDC converter[4c]
	Battery monitor side			Proper Insulation[5c]
	DepSW2 side			Proper Insulation[6c]

Note: Proper insulation (double insulation) is shown by green line in the figure above and singe insulation in black line.
All wires and components between the battery and the first power functions are assembled as double insulation.
The DCDC converter (LT3119) used for inhibit is a buck-boost converter and its internal FET configuration prevents reverse current

Figure 4-1 Inhibit schematic

Overcharge protection

Sep SW1, Sep SW2 and DCDC converter are equipped in the solar cell side or the GND side of the battery as shown in Figure above. DCDC converter controls the input voltage from the solar cells to the battery pack to 4.2V.

Over dis-charge protection

(Load Side)

Sep SW2, Sep SW3 and SepSW4 are equipped in the Load side of the battery as shown in Figure 4-1.

(Solar cell Side)

Sep SW2, DCDC convertor and Isolation diodes are equipped in the Solar cell side of the battery as shown in Figure 4-1.

(DepSW2 Side)

Dep SW2 is equipped in the HOT side as shown in Figure 4−1. Double Insulation is set between the battery and the DepSW2. Proper charging before satellite delivery. This work is confirmed as VTL.

External short protection

(Load Side)

Sep SW2 and Sep SW3 are equipped as shown in Figure 3. And double insulation is set between battery and Separation Switches.

(Solar cell Side)

Sep SW2 and DCDC convertor are equipped as shown in Figure 3. And double insulation is set between battery and Separation Switch and DCDC convertor.

(External power supply Side)

Sep SW2 and DCDC convertor are equipped as shown in Figure 3. And double insulation is set between battery and Separation Switch and DCDC convertor.

(Battery monitor Side)

Sep SW2 is equipped in the GND side of the battery as shown in Figure 3. Double insulation is set between battery and Battery monitor connector. The battery monitor connector terminal will be covered with Kapton and double insulated at the time of satellite delivery. This work is confirmed as VTL.

(DepSW2 Side)

Sep SW2 is equipped as shown in Figure 3. Double insulation is set between the Drain of SepSW2 and the battery and the Gate of Sep SW2.

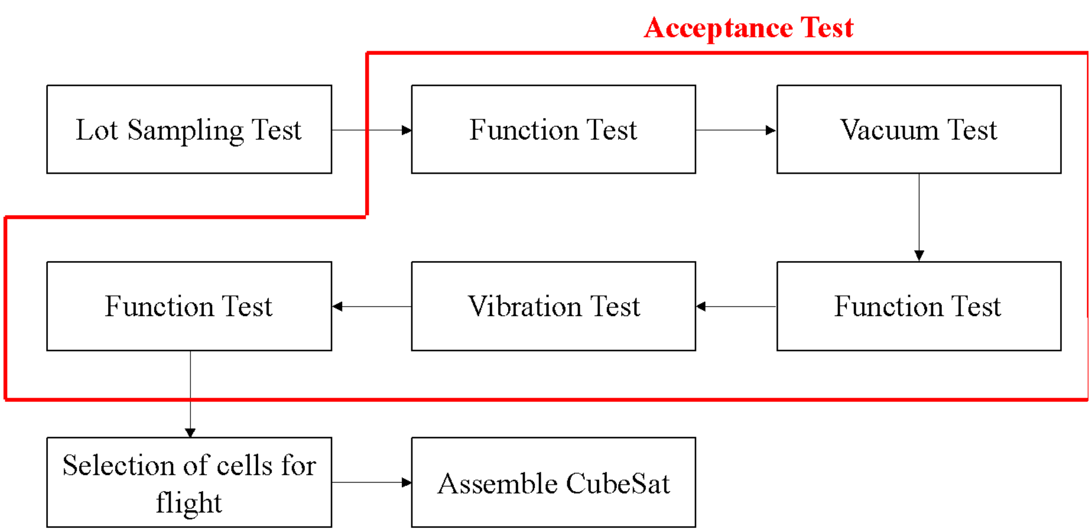
Summary of circuit protections and include trip/reset points (i.e., fuses, diodes, MOSFETs, resistors, source isolation, etc.):

Covered cables are used from the battery to GND or the first inhibit. The covered cables are further covered with Kapton tape to provide double insulation. In addition, GND and HOT terminals on a surface of a circuit board are covered with RTV, and the surface is covered with Kapton tape for double insulation.

Battery testing complete and report uploaded to this HR? Yes: ☐ **No:** ☒

If yes, provide a short summary test results including anomalies or failures.

Summary of safety testing performed or planned:



Flowchart for screening test

Following tests are performed for battery cells.

1. **Lot sampling Test**

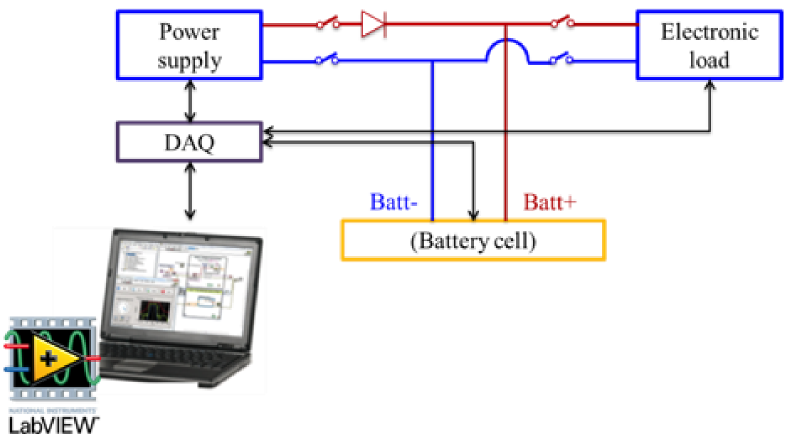
   (1) Thermal Test

   Thermal test of battery cell is performed for confirmation of temperature tolerance. Test condition is summarized as below.

- Temperature: more than +60 degree C
- Test Duration: Over 2 hours

Before and after the thermal test, several function tests below are performed to see that there is no change in characteristics.

- Visual inspection (scratches, misaligned seals, electrolyte leakage, etc.)
- Open Circuit Voltage (the change is less than 0.1%)
- Mass (the change is less than 0.1%)
- Capacity (the change is less than 5%)
- Charge/Discharge Characteristic
- Discharge Temperature



Charge/Discharge Characteristics Test Configuration

2. Acceptance Test

(1) Random Vibration Test

Random vibration test for flight cells is performed for screening purpose.

Test condition is summarized as below.

- Vibration Level: Minimum Screening Level (MSL)
- Tolerance: +/- 1.5dB for PSD
- Direction: 2 axes (Radial direction and Axial direction)
- Test Duration: Over 60 sec

Table 4-1 Random Vibration Level for cells

Freq. [Hz]	PSD [G^2/Hz] (MSL)
20	0.01
80	0.04
350	0.04
2000	0.007
Overall	6.06 Grms
Duration	1 min/axis

(2) Vacuum Test

Vacuum test of battery cell level is performed for screening. Test condition is summarized as below.

- Vacuum Level: less than 0.1 psia
- Test Duration: Over 6 hours

(3) Function Test

Before and after the environment tests (vibration test and vacuum test), several function tests below are performed to see that there is no change in characteristics.

Note that the Charge/Discharge Characteristics test measures the range between maximum voltage and minimum voltage.

Test Load: 1.9 [A] **In general, test is conducted with load between 0.2C and 1.0C*

Test Contents;

- Visual inspection (scratches, misaligned seals, electrolyte leakage, etc.)
- Open Circuit Voltage (the change is less than 0.1%)
- Mass (the change is less than 0.1%)
- Capacity (the change is less than 5%)
- Charge/Discharge Characteristic
- Discharge Temperature

3. Safety Function Test for System

(1) Function Test for system

After assembling the satellite, before and after the environmental test, the following functional tests are performed to confirm that there are no problems with the assembled battery.

Test content

- Open Circuit Voltage (Everyday for a 5 days)
- - Take measurements once a day

\- - No testing using the battery will be performed during this test.

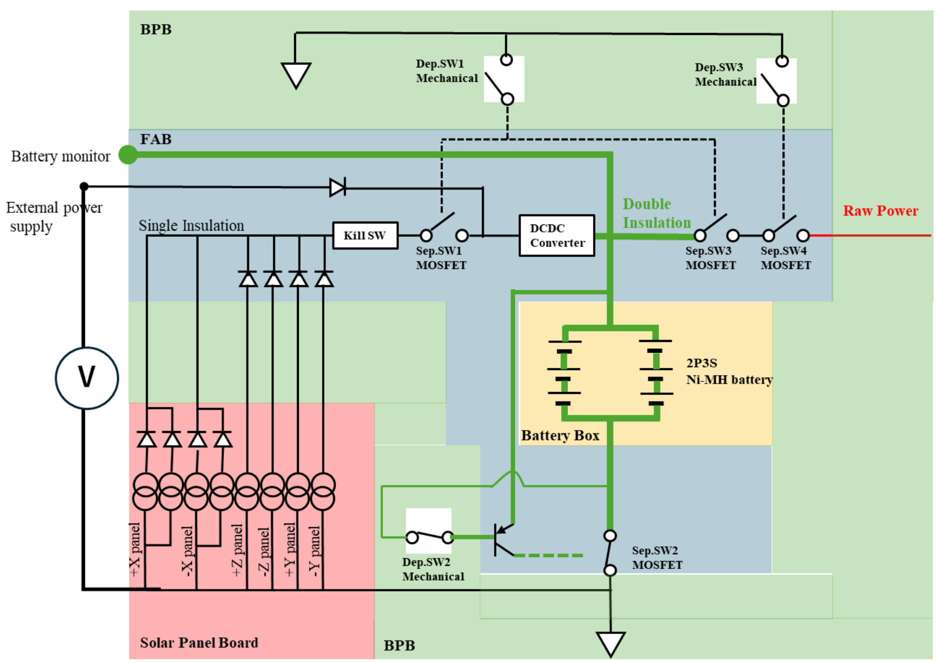
(2) Function Test for safety function

DC/DC converter test against overcharging is conducted before/after the FM vibration test. Function of separation switches (Sep SW) will be confirmed after the FM vibration test. Functional tests are performed with the board assembled, but the solar panel is not assembled because the test is performed using the input line from the solar panel. To evaluate the electronic elements after the environmental test, the satellite must be disassembled, which is risky, so the evaluation is performed before the environmental test. On the other hand, mechanical switches are inspected after the environmental test because they may be broken in the environmental test. DC/DC converters and diodes are performed to vibration tests using a EM board to confirm environmental resistance.

・SepSW1 test

SepSW1 is on the battery charging line from solar panels. Place the satellite in front of a solar simulator with all Dep SW pressed.

When the satellite is exposed to the light of the solar simulator, the Inhibit (SepSW1) prevents the battery from charging when DepSW1 is pressed. On the other hand, after DepSW1 is released, the voltage will be applied to the battery line. Therefore, the soundness of SepSW1 can be confirmed by checking the source voltage to the battery from the solar panels.



<u>**Figure 5 SepSW1 test configuration**</u>

・SepSW2,3,4 test

Connect the debugger to the access port of the satellite so that serial data from the satellite can be output to an external PC.

When the satellite is in OFF-state and the debugger is connected between the satellite and the PC, there should be no output the serial data in the PC display. OFF-state of the satellite is when one of the Inhibits are pressed.

On the other hand, the satellite is in ON-state when all inhibits are released, as such, the satellite should display information on the PC.

SepSW1 and SepSW3 can be operated by DepSW1, SepSW2 can be operated by DepSW2, and SepSW4 can be operated by DepSW3.

Check the serial data output when DepSW1, 2, and 3 are turned on respectively, and check the function of SepSW2, 3, and 4.

・DCDC convertor test (for overcharge)

The output of the solar cell is regulated by one DCDC converter to charge the battery. Connect an external power supply to the Back Plane Board and simulate the input voltage from the solar cell. Then, measure the DCDC output voltage from the connector that connects to the battery. The battery overcharged voltage is 4.8 V or higher. When the DC/DC input voltage is supplied by 5.2 V, we inspect the DC/DC output voltage should be below 4.2V by measuring the voltage at the battery slot.

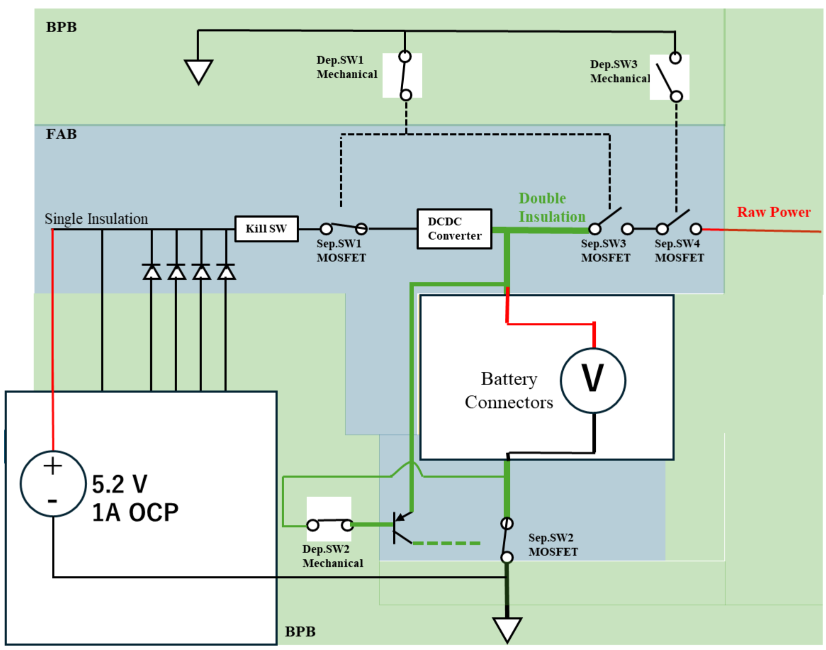


Figure6 DCDC convertor test configuration

・DCDC convertor test (for over-discharge and external short)

Ensure that the DCDC converter prevents reverse current flow. Connect an external power supply to the FAB board instead of the battery. With DepSW2 turned on, check the voltage on the input and output sides of the DCDC converter. Verify that the voltage from the external power supply is applied to the output side and that the voltage is not applied to the input side.

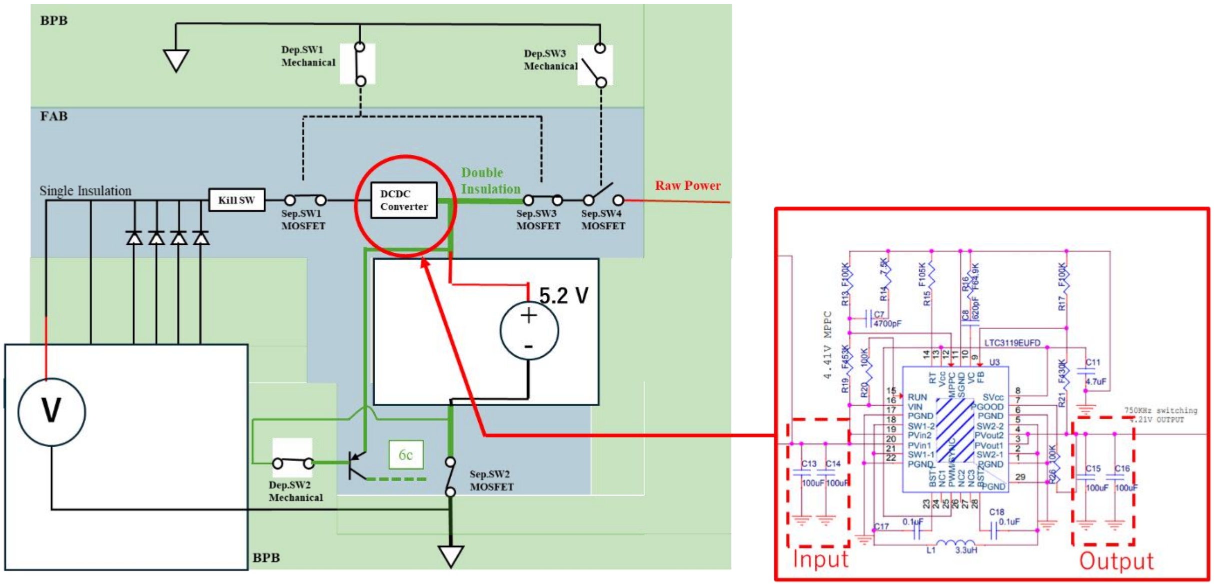


Figure7 DCDC convertor test configuration

・**Diode test** (±Y and ±Z Solar cell side)

In order to check if current flows in the reverse direction of the diode, an electronic load is connected in place of the solar panels. The anode side of the diode under test is connected to the electronic load and a power supply is connected to the cathode side of the diode under test. When the electronic load is activated to draw current, the diode should prevent it from doing so.

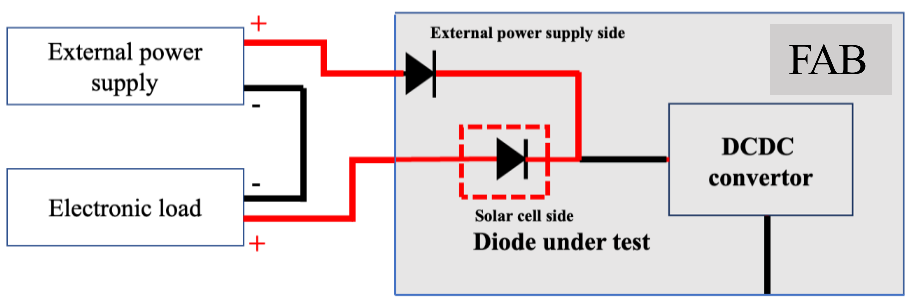


Figure 8 Diode test configuration

・**Diode test** (±X Solar cell side)

In order to check if current flows in the reverse direction of the diode towards the solar cell, a resistor is connected at the solar panel board as it is connected to the anode side of the diode under test which then connected in series with a Digital Multimeter (set as ammeter) with negative probe connected to negative terminal of the power supply and the solar panel board (GND). The resistor serves as a load that will draw current from the solar panel board or from the battery. The power supply connect to the power line on the solar panel towards the battery. When the power supply is activated, it will provide current flow to the solar panel board. However, with the diode in between, there should be no current flowing as read by the connected digital multimeters.

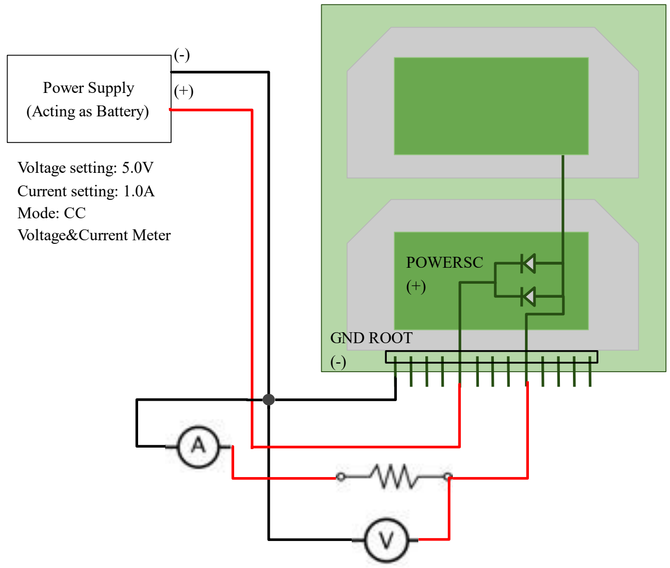


Figure 9 Diode test configuration

Has the pre-flight processing, flight acceptance plan, on-orbit processes, operational constraints, and the on-orbit and post-flight battery disposal plan for the hardware been conducted in accordance with JWI 8705.3?

Yes: ☐ No: ☒ If yes, provide accompanying documentation.

No on-orbit processing of the battery is planned before CubeSat deployment from ISS.

CubeSat including the battery will not return to the ground but will be burned up at atmospheric reentry.

Document No.#24-001, Date of review: Apr. 19. 2024

Appendix C-3 Toxicity Analysis (HMST)

Common Batteries HAZARDOUS MATERIALS SUMMARY TABLE Applicable sheet

[Sat] ASCENT to ISS Increment ALL

Batteries Name	Chemicals or BiologicalMaterials Commonly Flown Battery Chemistries	QTY	Applicable Parts Batteris Including Parts Name (P/N,S/N)	QTY
BK-3MCC	Nickel Metal Hydride - NiOOH/metal alloy/KOH	6	DRAGONFLY-FM-01	1

FINAL HAZARDOUS MATERIALS SUMMARY TABLE
ASCENT to ISS Increment ALL

Verification Status
V-1: *Previously Flown*
V-2: *N/A*

Expt /Hdwr/Item: **Common Batteries**

Expt/HW Acronym: **NA**

OpNom:

Record # Common.Bat — **PAYLOAD CHEMICAL or BIOLOGICAL INFORMATION**

Last Modified 9/14/20

Part #	Sub-System	Label	Chemicals or Biological Materials	Maximum Concentration	Maximum Volume or Amount	Tox Lvl	BioSafety Lvl	Flammability Haz Lvl
	Batteries	Batteries	Commonly Flown Battery Chemistries **Alkaline** Zn/MnO2/KOH **Zinc Carbon** Zn/carbon rod/NH4Cl (ZnCl2) **Lead Acid** Metallic Pb/PbO2/H2SO4 **Lithium Ion** LiCoO2, LiNMC, LiNCA LiMO2, LiFePO4, LiMOx LiTi4O5 or lithium alloys of Si or Sn LiPF6, LiBOB, LiBF4 or other **Lithium Primary** Li-MnO2; LiFeS2; LiCFx **EXCLUDING:** Li-SOCl2, Li-SO2 Li-SO2Cl2, and Li-BCX **Nickel-Cadmium** NiOOH/Cd(OH)2/KOH **Nickel-Hydrogen** H2/Ni(OH)2/KOH **Nickel Metal Hydride** NiOOH/metal alloy/KOH **Silver-Zinc** ZnO/Ag/KOH **Silver Oxide** Ag2O/Zn/KOH or NaOH **Zinc Air** Zn/Air/KOH	NA	NA	2	NA	0

HAZARD RESPONSE LEVEL (HRL) = 2

SPECIFIC HAZARD LEVELS

Toxicity (THL) **2** BioSafety (BSL) **NA** Flammability **0**

Target Organ(s): Eye, Skin

Principal Adverse Effects:

Electrolytes contained in batteries may cause severe eye irritation and possible permanent eye damage when they come into contact with the eyes.

SPECIAL NOTE: THIS RECORD DOES **NOT** COVER BATTERIES WITH THL > 2, WHICH ARE GENERALLY NOT ALLOWED IN THE HABITABLE VOLUME OF SPACECRAFT. Batteries containing sulfur dioxide and/or thionyl chloride may be THL 4 and **MUST** be assessed separately. Toxic vapors from batteries with THL 4 chemistry can be life threatening to crew (reference memo SF23-07-073).

Contact: David Delafuente, david.a.delafuente@nasa.gov, 281-244-8268

Comments: Most batteries contain electrolytes that are rated THL 2. It is therefore prudent to assume that all batteries contain irritating or corrosive electrolytes. **NOTE:** As of May 21, 2019, specific battery information will now be contained within the battery/capacitor spreadsheet located in IHS record #48243.

ECLS Environmental Rating = **NA** ECLS Hardware Rating = **NA**

As of September 14, 2020 3:50:50 PM Page 1 **Record # Common.Bat**

Currently assessed by:
Mission Toxicologist: JSC Toxicology

Appendix C-4 ISS EME Tailoring/Interpretation Agreement

ISS Electromagnetic Effects Panel Tailoring/Interpretation Agreement

SUBMITTAL DATE	AGREEMENT NO.	REV.	FLIGHT #(s)	1 of 2
2014/05/30	TIA # 1416	a.	NFS	

SYSTEM	ORIGINATOR and PHONE NO.	ORGANIZATION / CONTRACTOR
Flight Hardware	Masaru Wada/+81-50-3362-2377	JAXA, JEM

END ITEM/CONFIG. ID NO.	PART NUMBER(s)	DESCRIPTION	ASSEMBLY(s)	GFE	Payload
N/A	N/A	Cube Satellites EMI Testing	All elements excepts Russian element	No	Yes

SPECIFICATION NUMBER	SPEC. PARAGRAPH NO.	MANUFACTURER	CRITICALITY	SEVERITY
SSP 30237	3.1	N/A	3	3

ISSUE DESCRIPTION: (use continuation pages if required)

No EMI testing will be performed on the small satellites (CubeSats) to be deployed from JEM using NanoRacks CubeSat Deployer (NRCSD) or JEM-Small Satellite Orbital Deployer (J-SSOD).

TAILORING /INTERPRETATION AGREEMENT: (use continuation pages if required)

EMI testing required by SSP30237 is not mandatory for the cube satellites to be deployed from JEM using NRCSD or JEM-Small Satellite Orbital Deployer (J-SSOD).(See TIA 1268)

RATIONALE: (use continuation pages if required)

1) Satellites will not be activated during the launch and deployment phases from JEM. There are inhibits to prevent activation and the satellites are not activated until more than 1 mile away from the ISS.

2) Satellites comply with the criteria of Letter OE-14-002 “Intentional Radio Frequency Transmitter Hazards” as defined in the following table. .

Table TIA 1416-1 Electrical Field and Radiation Power Density by RF radiation

Frequency	RS03-10dB	Power density@RS03-10dB
14 kHz to 200 MHz	1.58 V/m (124dBuV/m)	0.0066 (W/m^2)
200 MHz to 8 GHz	19 V/m (145.6dB uV/m)	0.955 (W/m^2)
8 GHz to 10 GHz	6.3 V/m (136dB uV/m)	0.106 (W/m^2)
10 GHz to 13.7 GHz	☎Linear➂	☎Linear➂
13.7 GHz to 15.2 GHz	79 V/m (158dB uV/m)	16.58 (W/m^2)

Note: The frequency interference will be reviewed by the JSC Frequency manager through the dedicated process.

This is criticality 3 and severity 3 hardware. This TIA does not impose any operational constraints. This TIA is for all the ISS except the Russian Segment. **This is an interpretation.**

AGREEMENT DISPOSITION

PRIME EME	NASA EME	DATE	APPROVE	WITHDRAW	REJECT
George May	Matt McCollum	06/24/14	X		

COMMENTS:

06/24/14 TIA approved out of board.

Rev 02 October 2008

ISS Electromagnetic Effects Panel
Tailoring/Interpretation Agreement
Technical Concurrence

SUBMITTAL DATE	AGREEMENT NO.	REV.	FLIGHT #(s)	2 of 2
2014/05/30	TIA # 1416	a	NFS	

SYSTEM	ORIGINATOR and PHONE NO.	ORGANIZATION / CONTRACTOR
Flight Hardware	Masaru Wada/+81-50-3362-2377	JAXA, JEM

MEMBERS

NAME	DATE	ORGANIZATION
		Space Station Office, KSC
		Payloads Office, ISSP
		Engineering Directorate, JSC
		Safety and Mission Assurance/Program Risk Office, ISSP
		NASA Frequency Management Office
		Boeing Development Site – Huntsville
		Electrical Power Systems

AD HOC MEMBERS

NAME	DATE	ORGANIZATION
		Space Shuttle Program
		Operations Office, ISSP
		Boeing – Houston
		Subsystem or Tech. Discipline Area Requirement Owner, NASA ISSP
		Subsystem or Tech. Discipline Area Requirement Owner, Boeing ISSP
		Manager, ISSP Element
		Launch Package/Stage Manager
		Mission Operations Directorate, JSC
		International Partner Representative(s)

Appendix C-5 Hazard Analysis Verification for Space Radiation Analysis Group (SRAG)

ISS System/Payload:		Hazard Analysis Verification Space Radiation Analysis Group (SRAG)
Safety Review Panel POC:	Date: 01/28/2024	POC: Ramona Gaza
System/Payload POC: Takashi Yamauchi	MM/DD/YY	Alternate POC: Sabrina Houston

RF Emitter Name	Frequency [MHz]	Max Power [W]	Attenuator (Gain loss) [dB]	Max Gain [dBi]	Emitter Power Density [W/m^2]	Power Density Requirement [W/m^2]	Minimum Safe Distance [m]	Hazard Severity	Payload Actions
BIRDS-X VHF COM	145.825	0.6	0	2	0.84	2.00	No Hazard	No Hazard	There is no Crew Hazard. Please submit this form to NIR SME and document on the THINCC form.
BIRDS-X UHF COM	437.375	0.96	0	0.5	0.95	2.92	No Hazard	No Hazard	There is no Crew Hazard. Please submit this form to NIR SME and document on the THINCC form.

General Notes (for System/Payload input as applicable):

Appendix C-6 Verification of solar cell power

Since walls of J-SSOD-R launch case are transparent, if there are not enough inhibits and all inhibits located on the closed circuit from solar cell to load are accidentally closed, there is possibility to generate power with solar cells and activate some function of satellite which may cause hazard. To prove this function are not activated with the power generated by light inside JEM, it is required to show the power for activating the function is larger than the generated power with solar cells.

[Presupposition]

All we got from JAXA are shown below.

1. Graph of Relative Intensity of 3 mode of GLA (General Luminaire Assembly) (Figure 5)
2. Value of Max Illuminance at 1m from deck*: 1,400 [lx]

*There are 8 GLA in every 1m on each standoff of AFT/OVHD and FWD/OVHD inside JEM PM as shown in Figure 6. It is little difficult to calculate the distance from all GLA to work space, so this value was calculated by considering the work space surrounded by 2 GLA which has 8 times power of real GLA for each are located on AFT/OVHD and FWD/OVHD. Thus, it is very conservative value.

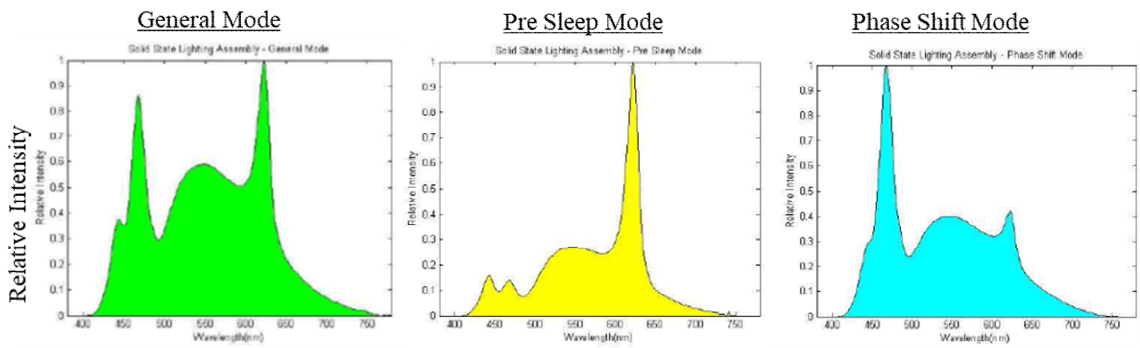


Figure 5: Relative Intensity

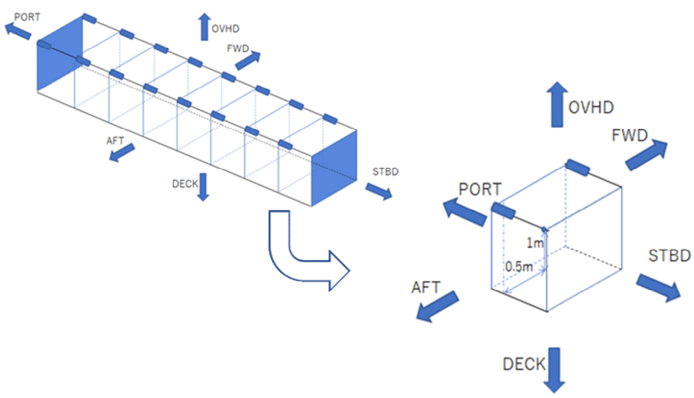


Figure 6: Illuminance inside JEM

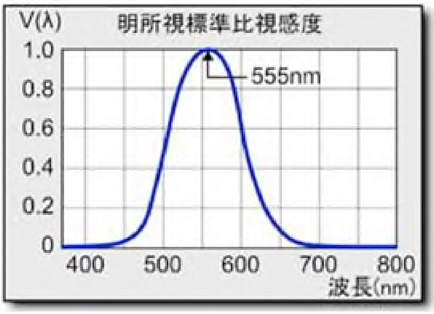
Illuminance is calculated by the following formula.

Illuminance[lx] = Σ (683[lm/W] x Luminosity Function @each wave length x Irradiance [W/m2)@each wave length)

= Σ (683 x A x Relative Intensity @each wave length x Irradiance [W/m2)@each wave length)

683: Max Luminous Sensitivity. Luminosity Function: shown right. It is defined as CIE1924., A: Absolute Irradiance/Relative Intensity

To get total irradiance [W/m2] of all wavelengths of the GLA, we have to integrate Irradiance @each wavelength. And, to get absolute Irradiance@ each wavelength, factor A (Absolute Irradiance/Relative Intensity) is needed. With the value read from each relative intensity graph, luminosity function and Max Illuminance 1400[lx], the whole irradiance was calculated, and the result are shown below.



General Mode

A: 3.32 x 10^-2

Irradiance: 4.47 [W/m2]

Pre-Sleep Mode

A: 7.26 x 10^-2

Irradiance: 4.19 [W/m2]

Phase Shift Mode

A: 5.32 x 10^-2

Irradiance: 4.69 [W/m2]

[Generated Power]

Spec, number of solar cells of DRAGONFLY is shown below.

Area of each solar cell: 0.003 [m2]

Number of solar cells: 16

Conversion Efficiency: 30 [%] * *Exact value of this solar cells is unknown.

So, theoretical max value is used.

The generated power on each mode is calculated as shown below.

General Mode

Generated Power : 4.47 x 0.003 x 16 x 0.3 = 0.0643[W]

Pre-Sleep Mode

Generated Power : 4.19 x 0.003 x 16 x 0.3 = 0.0603[W]

Phase Shift Mode

Generated Power : 4.69 x 0.003 x 16 x 0.3 = 0.0675[W]

[Required Power for Activate Function]

The function of the DRAGONFLY whose accidental activation may cause hazard are a heat cutter and a RF radiation. The heat cutter is activated by the OBC.

The minimum power required to operate the Reset PIC, which controls the power supply to the OBC and COM is shown below.

Activation of Reset PIC: 0.380 [W]

Conclusion

The required power for activating the het cutter and the COM is very larger than power generated with solar cells with light inside ISS, even Reset PIC cannot be activated with power generated with solar cells. Thus, there is no possibility to cause hazard by this function activation.

Appendix C-7 Implementation plan extracted from JAXA's checklist

Implementation plan extracted from JAXA's checklist for BIRDS-X

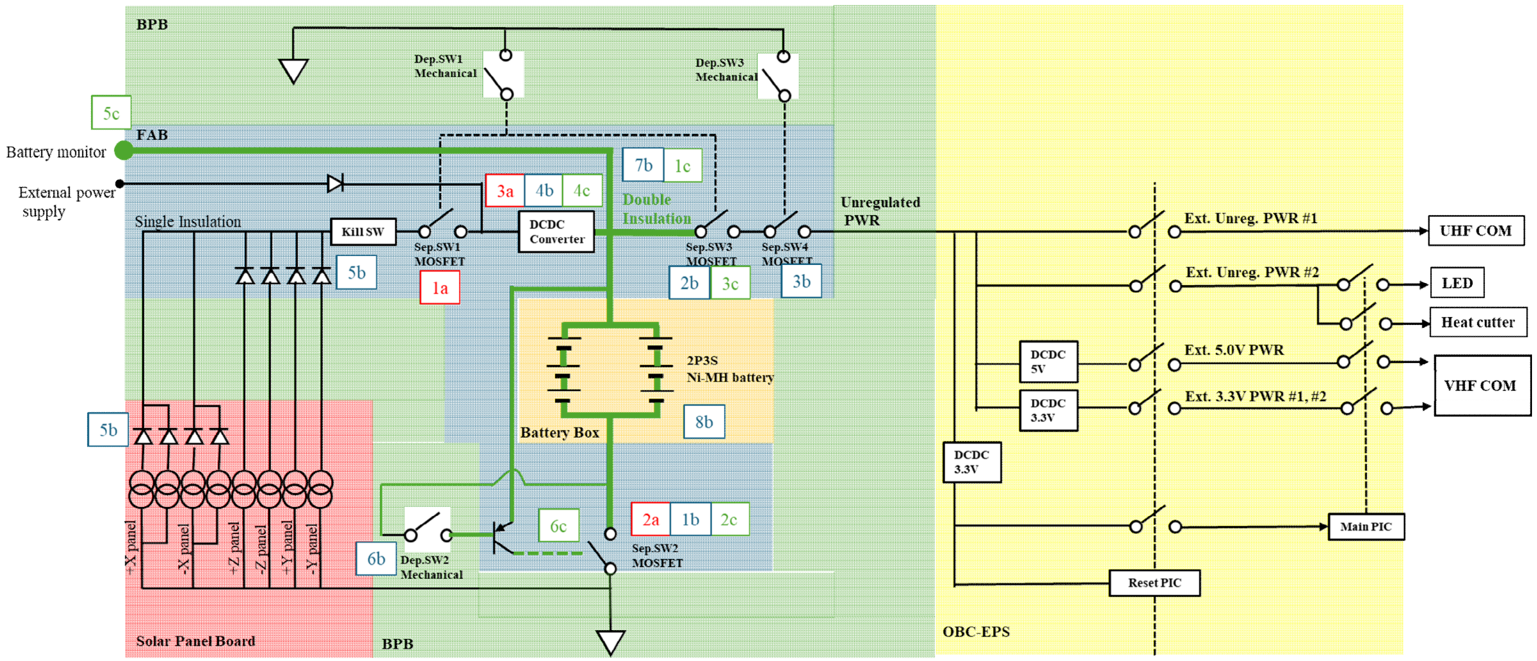
Items for DFMR	Implementation plan extracted from JAXA's checklist	Implementation result for BIRDS-X
(1) Inhibits on the positive AND negative current paths. (supply and return). This allows failure of one inhibit and still safe operations.	No chassis connection on the supply or return path between the battery and the inhibits. Any chassis connection must have an inhibit between the chassis and the battery to mitigate the effects of battery short circuits to chassis.	• See page 2
(2) Design to have no smart short between hot side and return side	Wiring: • Proper insulation (double insulation) • Wires connected to the battery positive and wires connected to the battery negative should not be in the same cable bundle. Or Additional insulation layers	• See *1 Wiring on page 3
	Battery: • Electrical connections to battery cells (tabs) should be insulated or covered with an insulating layer or cover. • Battery tabs and conductive surfaces covered with insulation to prevent shorting from conductive debris.	• See *2 Battery on page 3
	Circuit board: • Kapton tape to prevent shorting from FOD, etc.	• See *3 Board on page 4
	Connectors: • Either separate connectors for positive and negative conductors, or pin spacing on connectors between positive and negative sufficient to prevent shorting between positive and negative conductors if a connector pin is bent. • Cover the battery monitor connector terminal with Kapton.	• See *4 Connector on page 4 and 5

Implementation plan extracted from JAXA's checklist for BIRDS-X

No chassis connection on the supply path between the battery, DCDC convertor, DepSW2, Battery monitor terminal and SepSW3.

No chassis connection on the return path between the battery and SepSW2.

The Inhibit Schematic is shown on the right.



Hazard		Hazard Control #1	Hazard Control #2	Hazard Control #3
Over-charge		SepSW1[1a]	SepSW2[2a]	DCDC converter[3a]
Over-discharge	Load side	SepSW2[1b]	SepSW3[2b]	SepSW4[3b]
	Solar cell side		DCDC converter[4b]	Diode[5b]
	DepSW2 side	DepSW2 [9b]	Proper Insulation[7b]	Proper charging [8b]
External short	Load side	Proper Insulation[1c]	SepSW2[2c]	SepSW3[3c]
	Solar cell side			DCDC converter[4c]
	External power supply side			DCDC converter[4c]
	Battery monitor side			Proper Insulation[5c]
	DepSW2 side			Proper Insulation[6c]

Note: Proper insulation (double insulation) is shown by green line in the figure above and singe insulation in black line.
All wires and components between the battery and the first power functions are assembled as double insulation.
The DCDC converter (LT3119) used for inhibit is a buck-boost converter and its internal FET configuration prevents reverse current

Inhibit Schematic

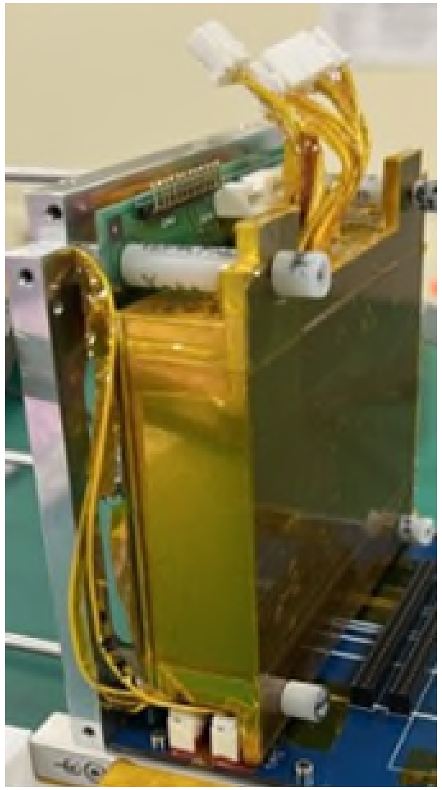
Implementation plan extracted from JAXA’s checklist for BIRDS-X

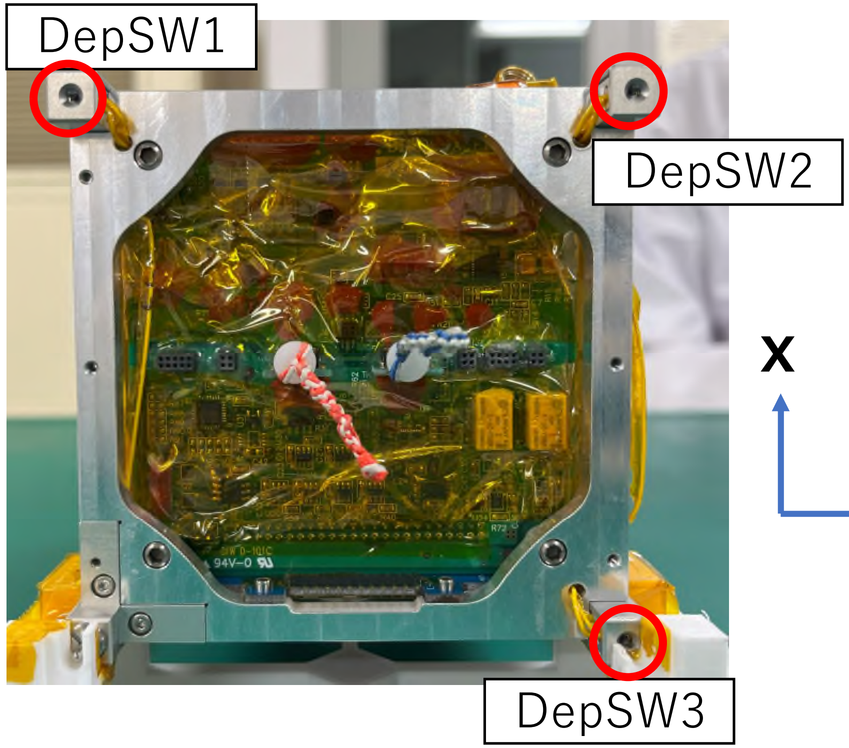
*1 Wiring

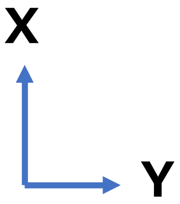
The power wires connecting the battery and the EPS1 board, and the wires of DepSW2 are double insulated (wire insulation and covering by Kapton tape).

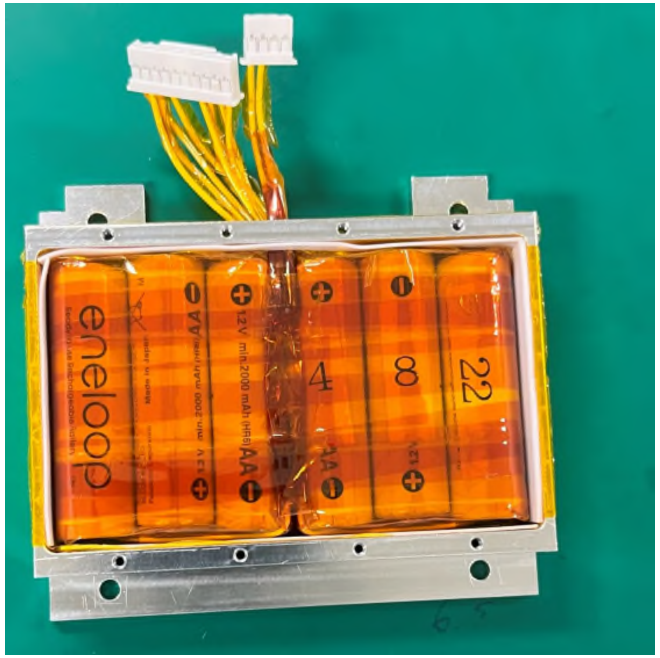
*2 Battery

Electrical connections to battery cells (tabs) are covered with Kapton tape.
Battery tabs and conductive surfaces are covered with Kapton tape.
The insulation sheets are installed between the battery box and the battery cells.





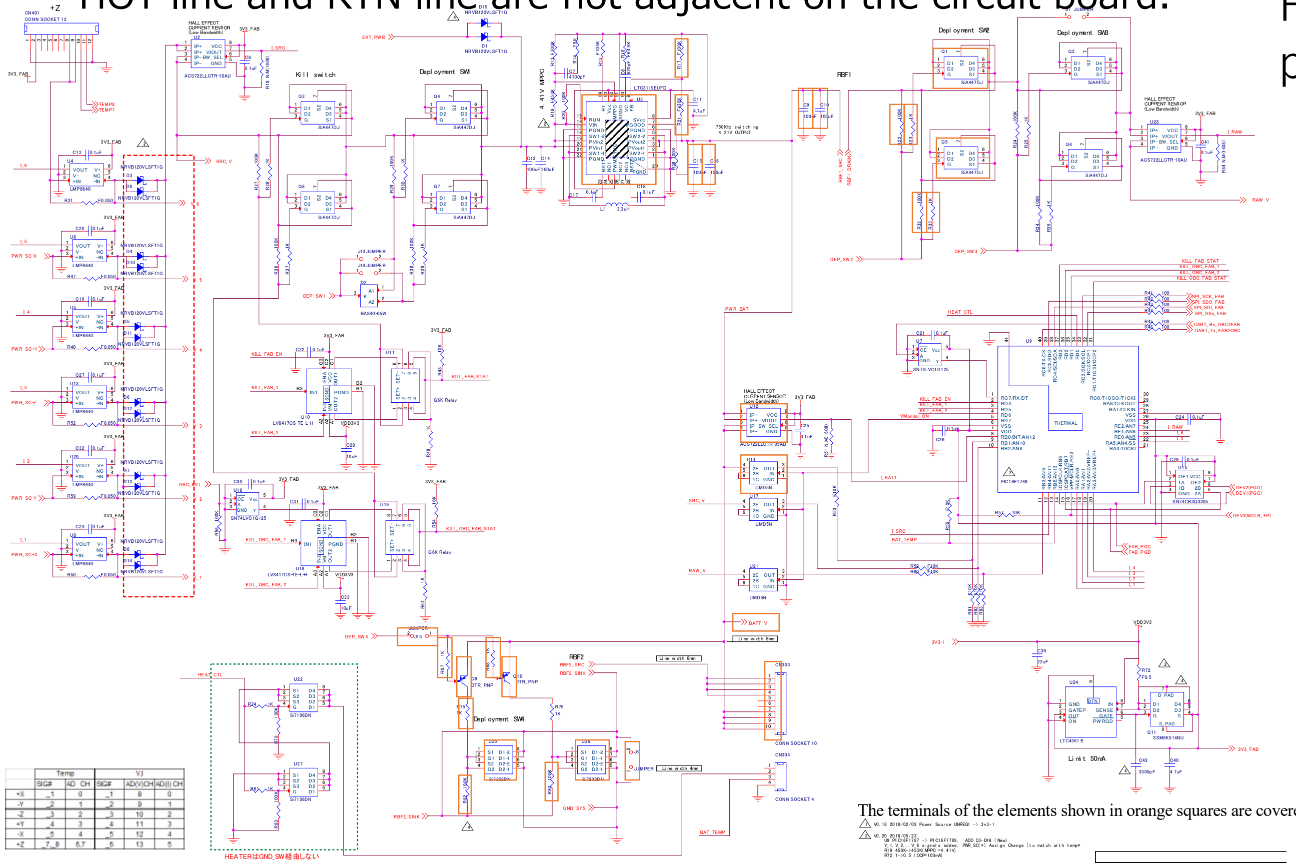




Implementation plan extracted from JAXA's checklist for BIRDS-X

*3 Circuit board

The terminals of the electronic elements (marked in orange) from the battery to the first inhibit are covered with RTV.
The entire EPS1 board is covered with Kapton tape.
HOT line and RTN line are not adjacent on the circuit board.



The terminals of the elements shown in orange squares are covered by RTV.

*4 Connectors

The pins spacing on connectors between positive and negative sufficient.

Power negative pins (four)

Power positive pins (four)

5.5mm

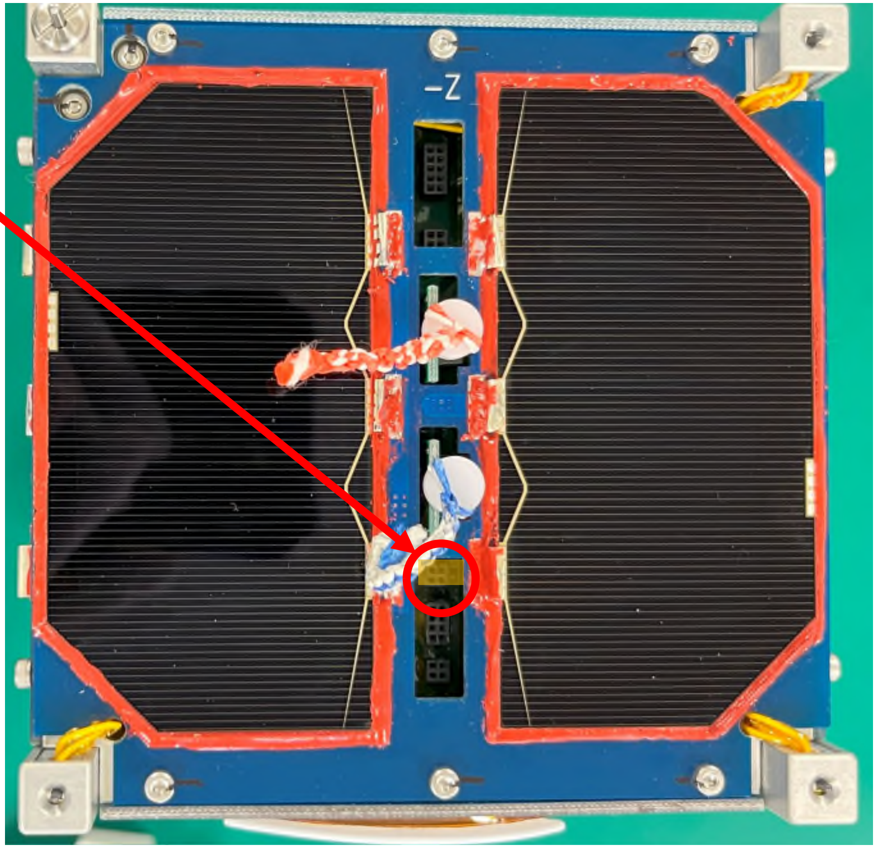
Y

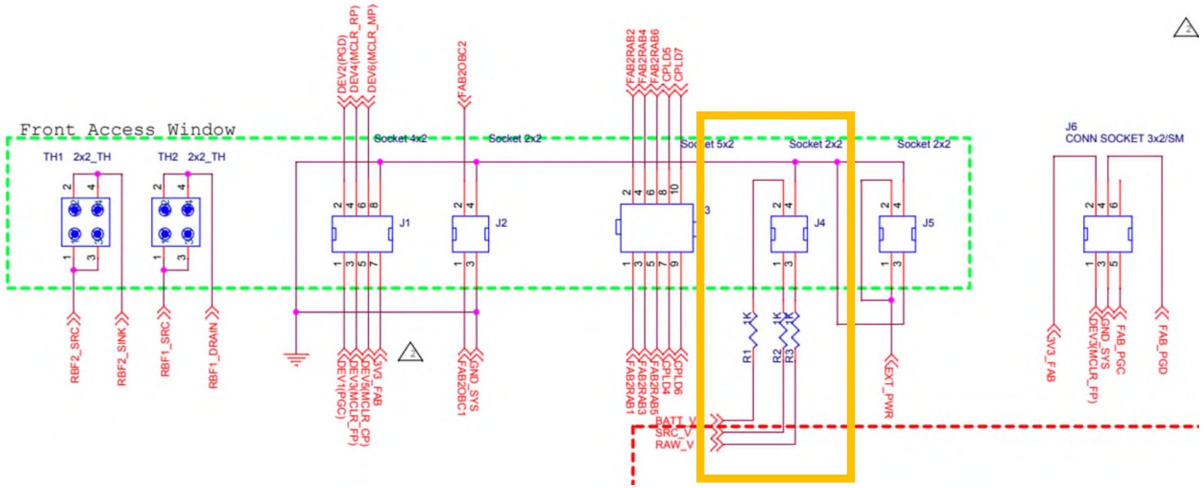
Z

Implementation plan extracted from JAXA's checklist for BIRDS-X

*4 Connectors

The battery monitor connector terminal to be covered with Kapton when the satellite is delivered.





Front Access Window Diagram
Battery Voltage could be monitored by Socket 2X2 (J4)

Appendix C-8 Selection of Wires and Circuit Protection Devices

Table STD-10 Selection of Wires and Circuit Protection Devices

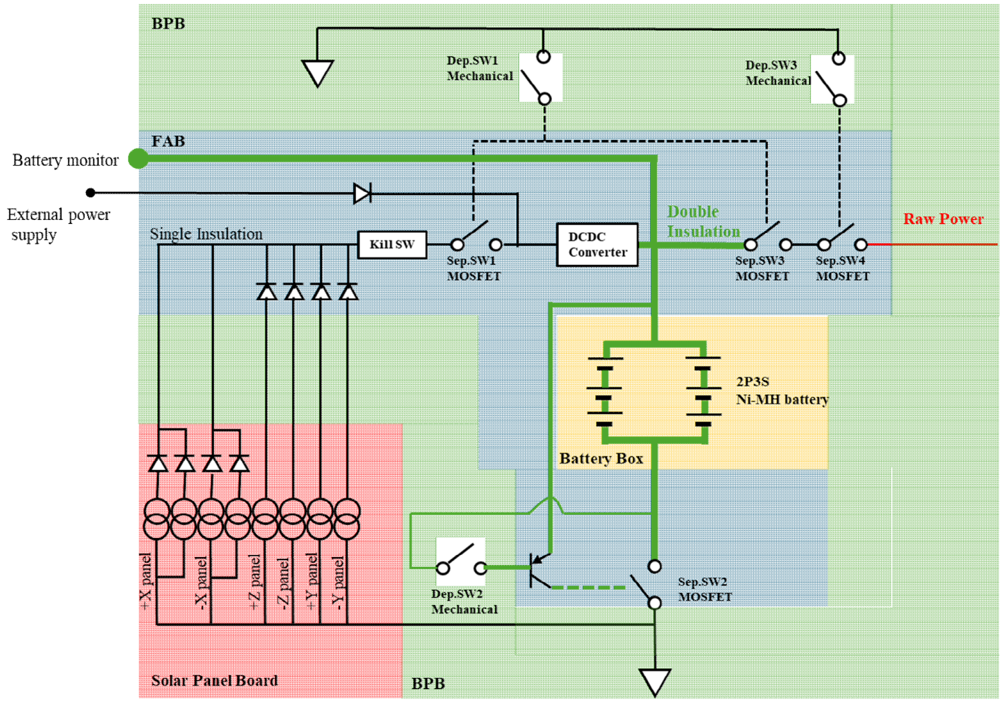
No.	Power Line Wire	Max. Applied Load(A)	Max. Blow Current of Protection Device (A)	Crew accessible Wire/Cables (Yes/No)	Downstream Wire									Compatibility for Wire Derating (Yes/No)	Compatibility for Touch Temperature (Yes/No)	Remarks
					Size (AWG)	Rated. Temp (°C)	Current Carrying Capacity of a Single Wire (A)	Current limit to meet touch temperature limited (A)[※2]	Quantity; Hot/Return	Bundled (Yes/No)	Bundle Factor	Derating Current (A)	Smart Short Current (A)			
1	DepSW2 signal line	267.4×10^{-6}	N/A	No	AWG30	200	1.3[※1]	-	1	No	N/A	1.3	N/A	Yes	-	
2	Battery cable	379.9×10^{-6}	N/A	No	AWG22	150	5.92[※3]	-	4 / 4	No	N/A	7.4	N/A	Yes	-	

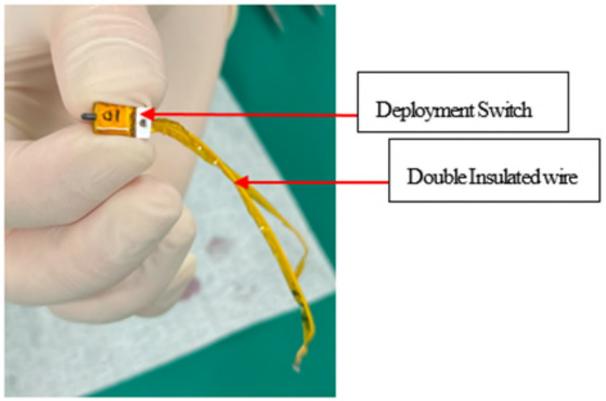
Note: Ambient Temperature +22.2°C, Ambient Pressure: 10^{-6} torr)

※1: Based on JAXA-JERG-2-212 5.2.1 Table 5.2-1 RECOMMENDED MAXIMUM CURRENT FOR SINGLE LINE as there was no indicattion of wire size to be used for SSP51721 4.3.1.2 Table 4.3.1.2-1.

※2: N/A because the target wire cannot be touched by the crew

※3: Based on SSP51721 4.3.1.2 Table 4.3.1.2-1 WIRE SIZE DERATING AND CIRCUIT PROTECTION Column A


BPB
Dep.SW1
Mechanical
Dep.SW3
Mechanical
FAB
Battery monitor
External power
supply
Single Insulation
Kill SW
Sep.SW1
MOSFET
DCDC
Converter
Double
Insulation
Sep.SW3
MOSFET
Sep.SW4
MOSFET
Raw Power
2P3S
Ni-MH battery
Battery Box
+X panel
-X panel
+Z panel
-Z panel
+Y panel
-Y panel
Dep.SW2
Mechanical
Sep.SW2
MOSFET
Solar Panel Board
BPB


Deployment Switch
Double Insulated wire

① Wire

AlphaWire

Alpha Wire | 711 Lidgerwood Avenue, Elizabeth, NJ 07207
Tel: 1-800-52 ALPHA (25742), Web: www.alphawire.com

Customer Specification
PART NO. 2841/7

Construction

		Diameters (In)
1) Component 1	1 X 1 HOOKUP	
a) Conductor	30 (7/38) AWG SPC	0.012
b) Insulation	0.006" Wall, Nom. PTFE	0.024+/- 0.002
(1) Color(s)	WHITE, BLACK, RED, GREEN, YELLOW, BLUE, BROWN ORANGE, SLATE, VIOLET	

Applicable Specifications

1) Military	MIL-W-16878/6 (Type ET)	
2) Other	NEMA HP3-ETXBBB	

Environmental

1) EU Directive 2011/65/EU(RoHS2):	
	All materials used in the manufacture of this part are in compliance with European Directive 2011/65/EU regarding the restriction of use of certain hazardous substances in electrical and electronic equipment. Consult Alpha Wire's web site for RoHS C of C.
2) REACH Regulation (EC 1907/2006):	
	This product does not contain Substances of Very High Concern (SVHC) listed on the European Union's REACH candidate list in excess of 0.1% mass of the item. For up-to-date information, please see Alpha's REACH SVHC Declaration.
3) California Proposition 65:	The outer surface materials used in the manufacture of this part meet the requirements of California Proposition 65.

Properties

Physical & Mechanical Properties	
1) Temperature Range	-60 to 200°C
2) Bend Radius	10X Cable Diameter
3) Pull Tension	0.88 Lbs, Maximum
Electrical Properties	(For Engineering purposes only)
1) Voltage Rating	250 V_{RMS}
2) Inductance	0.06 µH/ft, Nominal
3) Conductor DCR	94 Ω/1000ft @20°C, Nominal

Other

Packaging	Flange x Traverse x Barrel (inches)
a) 1000 FT	3.5 x 3 x 1.125 Max. 3 separate pieces; Min length/piece 100 FT.
b) 100 FT	2.75 x 1 x 1.125 Continuous length
	[Spool dimensions may vary slightly]
Notes:	
a) Certain colors and put-up combinations may only be available by special order, minimums may apply.	

www.alphawire.com
Alpha Wire | 711 Lidgerwood Avenue, Elizabeth, NJ 07207

Tel: 1-800-52 ALPHA (25742)

AlphaWire

EU/China ROHS CERTIFICATE OF COMPLIANCE

To Whom It May Concern:

Alpha Wire Part Number: 2841/7

2841/7, RoHS-Compliant Commencing With 3/1/2005 Production

Note: all colors and put-ups

This document certifies that the Alpha part number cited above is manufactured in accordance with Directive 2011/65/EU of the European Parliament, better known as the RoHS Directive (commonly known as RoHS 2), with regards to restrictions of the use of certain hazardous substances used in the manufacture of electrical and electronic equipment. This certification extends to amending Directive 2015/863/EU which expanded the list of restricted substances to 10 items (commonly known as RoHS 3) The reader is referred to these Directives for the specific definitions and extents of the Directives. No Exemptions are required for RoHS Compliance on this item. Additionally, Alpha certifies that the listed part number is in compliance with China RoHS "Marking for Control of Pollution by Electronic Information Products" standard SJ/T 11364-2014.

Substance	Maximum Control Value
Lead	0.1% by weight (1000 ppm)
Mercury	0.1% by weight (1000 ppm)
Cadmium	0.01% by weight (100 ppm)
Hexavalent Chromium	0.1% by weight (1000 ppm)
Polybrominated Biphenyls (PBB)	0.1% by weight (1000 ppm)
Polybrominated Diphenyl Ethers (PBDE) ,	
Including Deca-BDE	0.1% by weight (1000 ppm)
Bis(2-ethylhexyl) phthalate (DEHP)	0.1% by weight (1000 ppm)
Butyl benzyl phthalate (BBP)	0.1% by weight (1000 ppm)
Dibutyl phthalate (DBP)	0.1% by weight (1000 ppm)
Diisobutyl phthalate (DIBP)	0.1% by weight (1000 ppm)

The information provided in this document and disclosure is correct to the best of Alpha Wire's knowledge, information and belief at the date of its release. The information provided is designed only as a general guide for the safe handling, storage, and any other operation of the product itself or the one that it will become part of. The intent of this document is not to be considered a warranty or quality specification. Regulatory information is for guidance purposes only. Product users are responsible for determining the applicability of legislation and regulations based on their individual usage of the product.

Authorized Signatory for the Alpha Wire:

Dave Watson, Director of Engineering & QA 9/29/2020

Alpha Wire

711 Lidgerwood Ave.

Elizabeth, NJ 07207

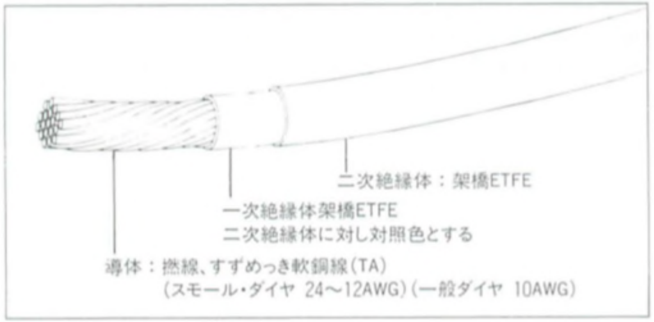
Tel: 1-908-925-8000

② Wire

MIL-W-22759

航空宇宙機器用MIL規格ジュンフロン架橋ETFE(XL ETFE)電線

個別仕様書番号：MIL-W-22759／34C　定格：600V、150℃　認定番号：M-22759-82-0451B



導　体： ASTM B 33に適合するすずめっき軟銅撚線(TA)です。
絶縁体： 架橋ETFEを導体上に均一の厚さに被覆し、絶縁体とします。
色　別： 色別は、絶縁体によって行ないMIL-STD-104に適合する黒、茶、赤、橙、黄、緑、青、紫、灰、および白の10色です。

部品番号(注)	導体				絶縁体外径		導体抵抗 20℃、最大	質量 最大
	AWG	構成	外径 最小	外径 最大				
		No.×AWG(本／mm)	inch(mm)	inch(mm)	inch	mm	Ω／km (Ω／1000ft)	kg／km (1bs／1000ft)
M22759/34-24-※	24	19×36(19/0.127)	.023(0.584)	.026(0.635)	.045±.002	1.143±0.051	86.0 (26.2)	3.48(2.3)
M22759/34-22-※	22	19×34(19/0.160)	.029(0.737)	.033(0.787)	.050±.002	1.270±0.051	53.2 (16.2)	4.83(3.2)
M22759/34-20-※	20	19×32(19/0.203)	.037(0.940)	.041(1.041)	.058±.002	1.473±0.051	32.4 (9.88)	7.05(4.7)
M22759/34-18-※	18	19×30(19/0.254)	.046(1.168)	.051(1.295)	.070±.003	1.778±0.076	20.4 (6.23)	10.78(7.2)
M22759/34-16-※	16	19×29(19/0.287)	.052(1.321)	.058(1.473)	.077±.003	1.956±0.076	15.8 (4.81)	13.46(9.0)
M22759/34-14-※	14	19×27(19/0.361)	.065(1.651)	.073(1.854)	.094±.003	2.388±0.076	10.0 (3.06)	20.61(13.8)

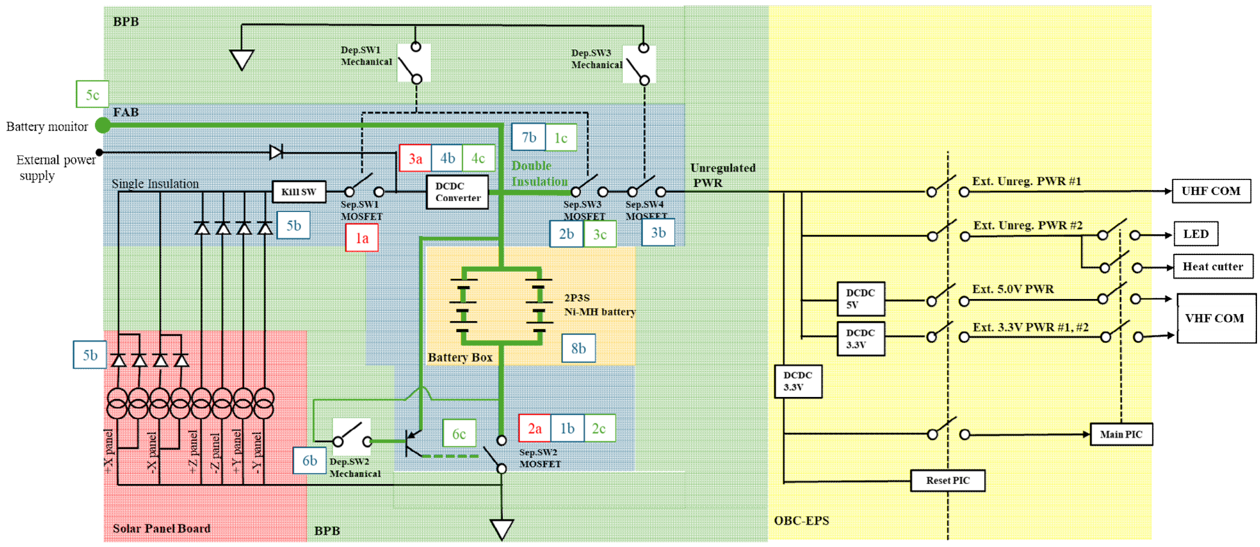
There is likelihood to activate FET and transistor under radiated electric field in ISS. But, since all FETs and transistors involved in the inhibit activate at more than 0.1 Volts, there is no chance of malfunction.

Figure 1 shows the inhibit circuit diagram. The red boxes indicate the FETs and transistors involved in the inhibit.

The specifications for these are shown.

The DCDC converter used as an inhibit uses four FETs inside.

These FETs are controlled by a logic circuit inside the DCDC converter, and the lines connecting them to the gates are extremely short. Therefore, no evaluation is required.



<u>Figure 1 EPS diagram</u>

Transistor: PDTA144E

SepSW1, 3, 4:SiA447DJ

SepSW2:Si7232DN

7. Characteristics

Table 8. Characteristics

T_{amb} = 25 °C unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
I_{CBO}	collector-base cut-off current	V_{CB} = −50 V; I_E = 0 A		-	-	−100	nA
I_{CEO}	collector-emitter cut-off current	V_{CE} = −30 V; I_B = 0 A		-	-	−1	μA
		V_{CE} = −30 V; I_B = 0 A; T_j = 150 °C		-	-	−5	μA
I_{EBO}	emitter-base cut-off current	V_{EB} = −5 V; I_C = 0 A		-	-	−90	μA
h_{FE}	DC current gain	V_{CE} = −5 V; I_C = −5 mA		80	-	-	
V_{CEsat}	collector-emitter saturation voltage	I_C = −10 mA; I_B = −0.5 mA		-	-	−150	mV
$V_{I(off)}$	off-state input voltage	V_{CE} = −5 V; I_C = −100 μA		-	−1.2	−0.8	V
$V_{I(on)}$	on-state input voltage	V_{CE} = −0.3 V; I_C = −2 mA		−3	−1.6	-	V
R1	bias resistor 1 (input)			33	47	61	kΩ
R2/R1	bias resistor ratio			0.8	1	1.2	
C_c	collector capacitance	V_{CB} = −10 V; I_E = i_e = 0 A; f = 1 MHz		-	-	3	pF
f_T	transition frequency	V_{CE} = −5 V; I_C = −10 mA; f = 100 MHz	[1]	-	180	-	MHz

[1] Characteristics of built-in transistor

Appendix C-9 Collision analysis immediately after deployment from J-SSOD

The release velocity of CubeSat is assumed to be 0.77 m/s which is the lower limit (JX-ESPC-101132-D1 Table4.3.1.2.2-1). The time until the CubeSat's heat cutter is turned on and the antenna is deployed is more than 20 s. The distance (X1) from J-SSOD (X1) until the satellite is released and the antenna deploys is X1=0.77*20=15.4 m.

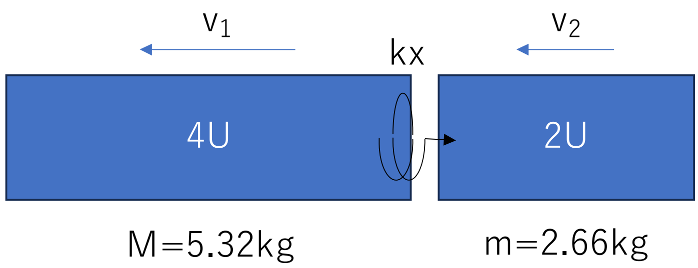


Figure 6.1-4 CubeSat separation velocity analysis

The satellite deployer can release up to 6U. Since this satellite is a 2U CubeSat, it is assumed that a 4U CubeSat is placed in front of it. The mass of 2U is m=2.66 [kg], the velocity after release is v2 [m/s], the mass of 4U is M=5.32 [kg], and the velocity is v1 [m/s]. The spring coefficient of the spring between the CubeSats is k, and the spring stroke x [m] is 0.75×10^{-3} [m]. The minimum spring force kx is 1.05[N].

The following formula holds from the laws of conservation of momentum and energy.

$$Mv_1 + mv_2 = 0$$

$$\frac{1}{2}Mv_1^2 + \frac{1}{2}mv_2^2 = \frac{1}{2}kx^2$$

Therefore,

$$\frac{1}{2}5.32 \times v_1^2 + \frac{1}{2}2.66 \times 4v_1^2 = \frac{1}{2}1.05 \times 0.75 \times 10^{-3}$$

$$v_1 = 0.007[m/s], \qquad v_2 = -0.014[m/s]$$

The separation speed v_1-v_2 between CubeSats after the CubeSats are released is 0.021 [m/s]. CubeSat takes more than 20 seconds after all isolation switches are turned on until the antenna deploys due to a malfunction. The distance between CubeSats after 20 seconds from CubeSat release is 0.42 [m].

When the deployable antenna is deployed, the distance from the ±Z rail end of the CubeSat to the antenna end is 0.267 [m]. From the above, even if the deployable object is erroneously deployed immediately after the CubeSat is released, it will not affect the J-SSOD or other CubeSats.

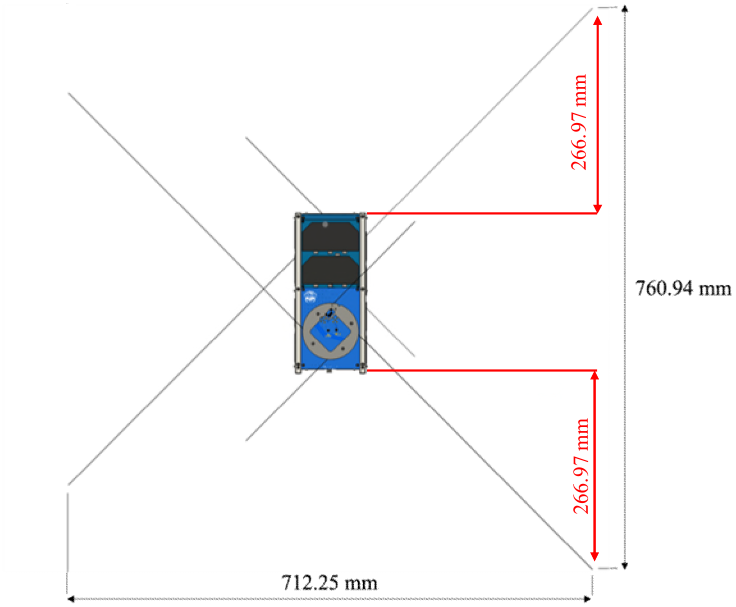
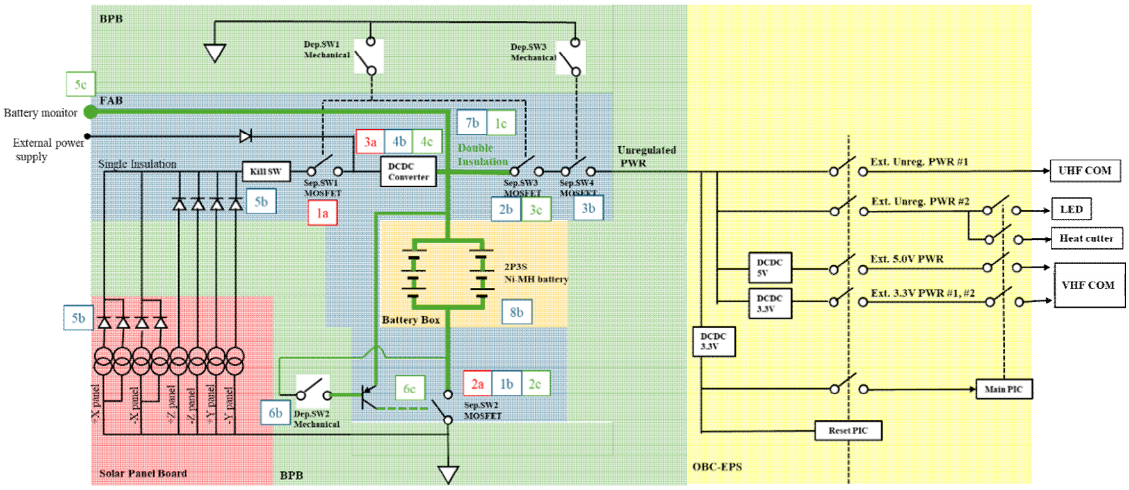


Figure C-9-1 Deployable antenna distance from CubeSat rail surface

Appendix C-10 Leakage current evaluation

The inhibit circuit of the BIRDS Bus has the circuit configuration shown in Figure C-10-1. The MOSFET (SepSW2) on the battery GND side is operated by turning the transistor ON and OFF with DepSW2. Considering the bias resistance inside this transistor, etc., closing DepSW2 in Figure C-10-2, causes current to flow through the bias resistance, etc. We analyzed the leakage current from the battery when two inhibit switches fail.



FigureC-10-1 Inhibit diagram

If DepSW1 and DepSW2 have an ON fault

Calculate the discharge current when DepSW1 and DepSW2 is turned on.

When DepSW1 is turned on and connected to GND, leakage current flows through the resistor placed in front of SepSW3 and FET in the DCDC convertor.

The following assumptions are made in the calculation.

・The main consumption currents are assumed to be I_1 to I_6.

・The bias resistance inside the transistor ranges from 33kΩ to 66kΩ, but as a worst-case scenario, R5, R6, R7, R8=33kΩ is assumed.

・R1, R2, R9, R10=1kΩ, R3, R4, R22, R32=100kΩ, R17=100kΩ, R21=430kΩ

・The battery voltage is assumed to be constant at 3.6V.

・Leakage current of the FET in the DCDC converter is 10 µA from the specification sheet (Table C-10-1)

Table C-10-1 Electrical characteristics of DCDC convertor

LTC3119

ELECTRICAL CHARACTERISTICS The ● denotes the specifications which apply over the specified operating junction temperature range, otherwise specifications are at $T_A = 25°C$. $V_{IN} = PV_{IN} = 12V$, $PV_{OUT} = 5V$, $R_T = 76.8k$ unless otherwise stated.

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
N-Channel Switch Resistance	Switch A (PV_{IN} to SW1) Switch B (SW1 to PGND) Switch C (SW2 to PGND) Switch D (SW2 to PV_{OUT})			30 30 30 30		mΩ mΩ mΩ mΩ
N-Channel Switch Leakage	$PV_{IN} = PV_{OUT} = 18V$, SW1 = SW2 = 0V, 18V			1	10	μA
V_{CC} Regulation Voltage		●	3.55	3.70	3.85	V
V_{CC} Dropout Voltage	V_{CC} Current = 50mA, V_{IN} = 3V			90		mV
V_{CC} Current Limit			180			mA
V_{CC} Reverse Current	V_{CC} = 5V, V_{IN} = 3V			5		μA

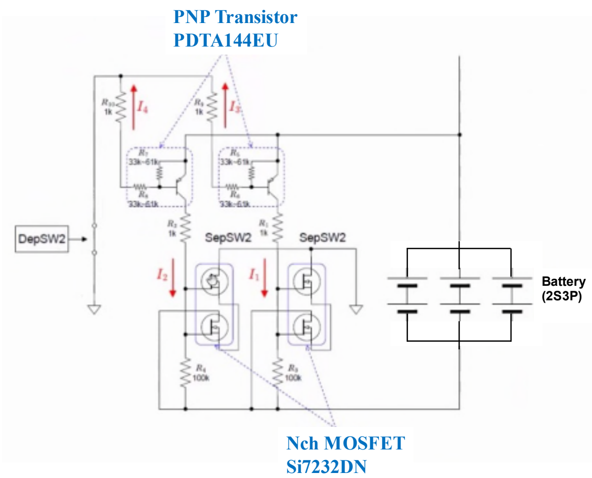


Figure C-10-2 Detail of the separation switch on GND side

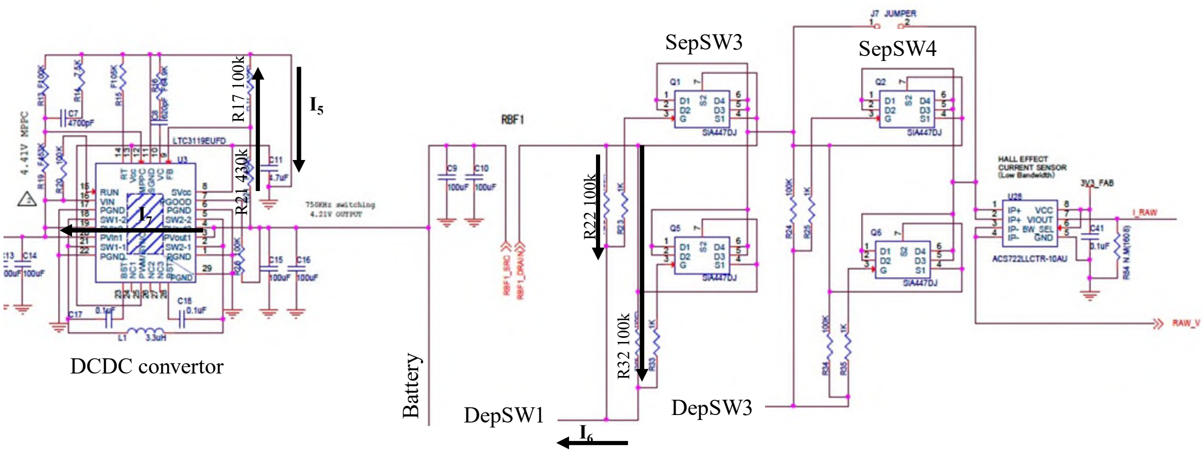


Figure C-10-3 Detail of the separation switch on HOT side

$$I_1 = \frac{V_{Bat}}{R_1 + R_3} = \frac{3.6}{10^3 + 10^5} = 35.6 \times 10^{-6}$$

$$I_2 = \frac{V_{Bat}}{R_2 + R_4} = \frac{3.6}{10^3 + 10^5} = 35.6 \times 10^{-6}$$

$$I_3 = \frac{V_{Bat}}{R_5 + R_6 + R_9} = \frac{3.6}{33 \times 10^3 + 33 \times 10^3 + 10^3} = 53.7 \times 10^{-6}$$

$$I_4 = \frac{V_{Bat}}{R_7 + R_8 + R_{10}} = \frac{3.6}{33 \times 10^3 + 33 \times 10^3 + 10^3} = 53.7 \times 10^{-6}$$

$$I_5 = \frac{V_{Bat}}{R_{17} + R_{21}} = \frac{3.6}{100 \times 10^3 + 430 \times 10^3} = 6.79 \times 10^{-6}$$

$$I_6 = \frac{V_{Bat}(R_{22} + R_{32})}{R_{22}R_{32}} = \frac{3.6(100 \times 10^3 + 100 \times 10^3)}{100 \times 10^3 \times 100 \times 10^3} = 72 \times 10^{-6}$$

$$I_7 = 10 \times 10^{-6}$$

$$I_{total} = I_1 + I_2 + I_3 + I_4 + I_5 + I_6 + I_7 = 267.39 \times 10^{-6}[A]$$

The total leakage current I_{total} is about 0.268 mA. The capacity at which the battery reaches over-discharge is 4,000 mAh, so if the battery is discharged from a full charge, it takes the following number of days for the battery to become over-discharged.

$$t = \frac{3800}{0.268} = 14.18 \times 10^3[h] \approx 590[day]$$

This number of days is well more than one year from satellite delivery to release. The calculations assume a fully charged battery at rated capacity. In an actual battery, the time until over-discharge is expected to be somewhat shorter than this calculation result, but it is still considered to be sufficient.

Appendix D Safety Verification Tracking Log (SVTL)

International Space Station
Safety Verification Tracking Log

Mission/Element			J-SSOD			Date:				
Log Number	Hazard Report Number	Safety Verification Number	Description (Identify Procedures by Number and Title)	Operation(s) Constrained	Independent Verification Required (Yes/No)	Scheduled Date	Completed by Project		Confirmation by JAXA S&PA	
							Completion Date	Method of Closure Comments/Verification Completion Notice (VCN)	Completion Date	Remarks As a Result of Independent Validation and Verification
1	BIRDSX-UNQ-01	1.1-1(1)	Inspection to verify that the satellites are installed per the approved packing requirement.	No	No			Review of the packing procedure record, JDX-2020471.		
2	BIRDSX-STD BIRDSX-UNQ-02	V-10.1(c) 1.2-2(3) 1.4-1(3)	Inspection to arify that the surface of the battery monitor terminal at the access port is covered with Kapton.	No	No					
3	BIRDSX-UNQ-02	1.4-2(2)	Confirm that the battery is in a state of final charge (SOC > 80%) at the time of delivery.	No	No					