CUBESPACE

CubeSense Sun Generation 2

Interface Control Document (ICD)

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Revision History

VERSION	AUTHORS	DATE	DESCRIPTION
A	C. Leibbrandt	15/06/2023	First draft release
B	R. van Wyk	25/07/2023	Review and additions
1.00	C. Leibbrandt	27/07/2023	First published release

Reference Documents

The following documents are referenced in this document.

[1] CS-DEV.PD.CS-01 CubeSense Sun Product Description Ver.1.00 or later

[2] CS-DEV.UM.CS-01 CubeSense Sun User Manual Ver.1.00 or later

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List of Acronyms/Abbreviations

ACP	ADCS Control Program
ADCS	Attitude Determination and Control System
CAN	Controller Area Network
COM	Centre of Mass
COTS	Commercial Off The Shelf
CSS	Coarse Sun Sensor
CVCM	Collected Volatile Condensable Materials
DUT	Device Under Test
EDAC	Error Detection and Correction
EHS	Earth Horizon Sensor
EM	Engineering Model
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
FDIR	Fault Detection, Isolation, and Recovery
FM	Flight Model
FSS	Fine Sun Sensor
GID	Global Identification
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GYR	Gyroscope
I2C	Inter-Integrated Circuit
ID	Identification
LTDN	Local Time of Descending Node
LEO	Low Earth Orbit
MCU	Microcontroller Unit
MEMS	Microelectromechanical System
MTM	Magnetometer
MTQ	Magnetorquer
NDA	Non-Disclosure Agreement
OBC	On-board Computer
PCB	Printed Circuit Board

RTC	Real-Time Clock
RWA	Reaction Wheel Assembly
RW	Reaction Wheel
SBC	Satellite Body Coordinate
SOFIA	Software Framework for Integrated ADCS
SPI	Serial Peripheral Interface
SRAM	Static Random-Access Memory
SSP	Sub-Satellite Point
STR	Star Tracker
TC	Telecommand
TCTLM	Telecommand and Telemetry (protocol)
TID	Total Ionizing Dose
TLM	Telemetry
TML	Total Mass Loss
UART	Universal Asynchronous Receiver/Transmitter

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1 Introduction

This document is written with the assumption that the reader is familiar with the CubeSense Sun as described in [1]. The purpose of this document is to provide Interface Control Document (ICD) related information about the CubeSense Sun.

This version of ICD applies to the CubeSense Sun hardware versions as stated in Table 1 below.

Table 1: Document Applicability

CUBEPRODUCT	VERSION	NOTES
CubeSense Sun	M2.0E4.5	

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2 Electrical Interface

This chapter describes the electrical interfaces of the CubeSense Sun. This includes:

1. Communication interfaces
2. Power interfaces and expected power levels, and
3. Harness details

2.1 CubeSense Sun Communication interface(s)

This section describes the configuration and characteristics of the following communication interfaces to the CubeSense Sun.

- CAN
- UART
- RS485 / RS422 (custom option)
- I2C (custom option)

2.1.1 CAN Characteristics

The characteristics for the CubeSense Sun CAN bus are given in Table 2.

Table 2: CAN bus characteristics for CubeSense Sun

PARAMETER	VALUE
Supported CAN standard	V2.0B
Supported bitrate(s)	1 Mbit/s
Supported protocol(s)	CubeSpace CAN Protocol, CubeSat Space Protocol (CSP)

2.1.2 UART characteristics

The characteristics of the CubeSense Sun UART interface are given in Table 3.

Table 3: UART characteristics for CubeSense Sun

PARAMETER	VALUE
Maximum supported Baud rate	921600 (configurable)
Data bits	8
Parity	None
Stop bits	1

2.1.3 RS485 / RS422 characteristics (custom option)

RS485 / RS422 communication with the CubeSense Sun is provided as a custom option and must specifically be specified by the client at the time of order placement. The UART characteristics of the RS485 / RS422 interface are the same as in Table 3. Additional RS485 / RS422 characteristics are given in Table 4

Table 4: RS485 / RS422 characteristics for CubeSense Sun

PARAMETER	VALUE
Data Enable (DE) polarity	High

2.1.4 I2C Characteristics (custom option)

I2C communication with the CubeSense Sun is provided as a custom option and must be specifically specified by the client at the time of order placement. The CubeSense Sun is always configured as a slave on the I2C bus and cannot initiate communications by itself. It is important to note that the master that communicates with the CubeSense Sun CubeComputer must support clock stretching. The relevant I2C characteristics for the CubeSense Sun are given in Table 5.

Table 5: I2C bus characteristics for CubeSense Sun

PARAMETER	VALUE
Maximum supported bitrate	1 Mbit/s (I2C Fast Mode Plus)
Addressing mode	7-bit configurable slave address
Clock stretching	Yes (master must support clock stretching)
Repeated-start support	Not supported

2.2 CubeSense Sun Power supply

Table 6 below summarizes the power supply voltages to be supplied by the client ADCS / OBC.

Table 6: CubeSense Sun external power supply requirements

EXTERNAL POWER	VALUE
Supply voltage [V]	3.3
Peak power [mW]	174
Average power [mW]	100

2.2.1 Power consumption: 3.3V rail

The CubeSense Sun has an average power consumption on the 3.3 V line independent of the satellite's size or ADCS modes used. This is as the basic digital circuit is designed to be common amongst the CubeProducts, and all are powered from 3.3V.

The average and maximum power consumption and the peak inrush current and duration on the 3.3 V line for the CubeSense Sun are shown in Table 7.

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Table 7: CubeSense Sun Average power consumption and inrush current on 3.3 V line

SUBSYSTEM	3.3 V RAIL					NOTES
	Avg Current (mA)	Avg Power (mW)	Max Current (mA)	Max Power (mW)	Inrush (mA – μs)	
CubeSense Sun	28	93	78	260	260-1000	Measured during 1 Hz detection.

2.2.2 Power Protection

CubeSense Sun Power Protection is included. Specifically, if the 3V3 power supplied externally falls outside the 2.5V – 3.9V range, the CubeSense Sun will automatically switch off.

It is however expected that the user follows the specifications provided for the CubeSense Sun system as specified in this document. Whenever any input or interface is used out of specified ranges, CubeSpace cannot ensure that the CubeSense Sun will function as intended.

2.2.2.1 CubeSense Sun Enable line.

The CubeSense Sun implements an externally controlled/controllable Enable line. The Enable line should be controlled by the client ADCS or OBC. The CubeSense Sun is enabled if the Enable line is active (high). If the CubeSense Sun Enable line is pulled low, the CubeSense Sun will be disabled.

2.2.2.2 CubeSense Sun 3V3 undervoltage protection/[danger]

The client ADCS / OBC should monitor the 3V3 rail voltage level and ensure that it is above the minimum threshold voltage before switching on the 3V3 to the CubeSense Sun. This will ensure protection of the CubeSense Sun from undervoltage conditions and helps protect memory and other sensitive circuits on the CubeSense Sun.

It is suggested that the client ADCS / OBC should provide current limiting for the 3V3 power supply to the CubeSense Sun and should also allow for latching off during a fault to protect against hard latch-up events.

The above functionality is available on the CubeADCS CubeComputer. If the CubeSense Sun is connected to the client ADCS / OBC, similar protection is suggested.

2.2.2.3 CubeSense Sun 3V3 power switch

The CubeSense Sun implements an input power switch. It is enabled by pulling the Enable line high for the CubeSense Sun. This switch allows the client ADCS / OBC to isolate it from the 3V3 power rail. The CubeSense Sun power switch also provides a current limit (400mA) feature to protect against hard-latch up events. It also has overvoltage protection set to trigger upwards of 3.9V (depending on thermal conditions).

2.3 Harnesses

The CubeSense Sun is designed to connect to the CubeComputer (or the client ADCS / OBC) via a dedicated harness with Molex Micro-Lock plus housings crimped on to each end.

The wire length between the housings can be specified from a selection of standard lengths. The client can specify the desired length when the order for the CubeSense Sun is placed.

If the client needs a different connector between the CubeSense Sun and the client ADCS / OBC, CubeSpace suggests that the standard CubeSense Sun harness is supplied and the ADCS / OBC side connector be replaced by the client with his desired connector – CubeSpace tries to focus on mass production of harnesses with a limited number of connector housing supported to ensure reliability and repeatability. “Custom” / non-standard CubeSpace connectors are avoided if possible.

The wire used has a PTFE insulation which is low outgassing.

The CubeSense Sun standard harness characteristics are described in Table 8 below. In Table 8, Housing 1 and terminal 1 mates with the client ADCS / OBC, and Housing 2 and terminal 2 mates with the CubeSense Sun itself.

Table 8: CubeSense Sun Harness characteristics

Harness	Housing 1 mass (mg)	Terminal 1 mass (mg)	Wire Gauge (AWG)	Wire mass (kg/km)	Housing 2 mass (mg)	Terminal 2 mass (mg)	pins	Total[1] Mass
CubeSense Sun Sensor	229.64	35.434	26	1.96	198.8	35.434	8	

2.3.1 CubeSense Sun Sensor Header on client ADCS / OBC

The client will be provided with a double-sided harness terminated with Molex Micro-Lock Plus single row 10 pin header (Molex 5055671081) and the applicable sensor header on the other end. The harness will be manufactured to the client specified length. If a single sided harness is required the client may cut off the one header from the harness, this must be considered when specifying the harness length to CubeSpace. The pinout of the supplied harness can be seen in Table 9.

Table 9: Sensor Harness Pinout

SENSOR HARNESS INTERFACE DETAILS				
Header Type:	Molex 5055671081			
Number of pins	10			
Mating Housing	Molex 5055651001			
Housing Terminal	5037650098			
CubeSense Sun Header pin definitions				
Pin #	Pin Name	Pin Description	IO Type	Voltage range [V]
1	BOOT	Active High boot line. Leave unconnected if unused.	Input	-0.3 to 3.4 $V_{low} < 0.5$ $V_{high} > 2.6$
2	I2C_DA	I2C data line	Serial data	2.7 to 5.5V $V_{low} < \sim 0.4$ $V_{high} > \sim 2.3$
3	3V3	Supply voltage for the digital electronics	Power	3.2 to 3.4
4	UART_TX (RS485_A)[1]	UART Data Transmit of MCU.	Output	-0.5 to 3.4
5	CAN_P	High level CAN bus line	Differential	-3.4 to 3.4
6	CAN_N	Low level CAN bus line	Differential	-3.4 to 3.4

[1] Total mass of the harness depends on the harness length. The total mass can thus be self-calculated using the wire mass (in kg/km) for the specified / selected harness lengths.

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SENSOR HARNESS INTERFACE DETAILS				
7	UART_RX (RS485_B)[1]	UART Data Receive of MCU. Pull high if unused.	Input	-0.5 to 3.4
8	GND	Power ground of electronics	Power	0
9	I2C_CLK	I2C Clock line	Serial Clock	2.7 to 5.5V V_{low} < ~0.4 V_{high} > ~2.3
10	Enable	Active high enable	Input	-0.3 to 3.4 V_{low} < 0.95 V_{high} > 1.05

[1]CubeSense Sun can be configured for RS485 or UART

2.3.2 Harness Header on CubeSense Sun

Table 10: CubeSense Sun interface details

CUBESENSE SUN INTERFACE DETAILS				
Header Type:	Molex 5055651001			
Number of pins	10			
Mating Housing	Molex 5055651001			
Housing Terminal	5037650098			
CUBESENSE SUN HEADER PIN DEFINITION				
PIN #	**PIN NAME**	**PIN DESCRIPTION**	**IO TYPE**	**VOLTAGE RANGE [V]**
1	BOOT	Active High boot line. Leave unconnected if unused.	Input	-0.3 to 3.4 V_{low} < 0.5 V_{high} > 2.6
2	I2C SDA	I2C data line	Serial data	2.7 to 5.5V V_{low} < ~0.4 V_{high} > ~2.3
3	3V3	Supply voltage for the digital electronics	Power	3.2 to 3.4
4	UART_TX (RS485_A)[1]	UART Data Transmit of MCU.	Output	-0.5 to 3.4
5	CAN_P/CAN_H	High level CAN bus line	Differential	-3.4 to 3.4
6	CAN_N/CAN_L	Low level CAN bus line	Differential	-3.4 to 3.4
7	UART_RX (RS485_B)[1]	UART Data Receive of MCU. Pull high if unused.	Input	-0.5 to 3.4
8	GND	Power ground of electronics	Power	0
9	I2C SCL	I2C Clock line	Serial clock	2.7 to 5.5V V_{low} < ~0.4

CUBESENSE SUN INTERFACE DETAILS

				V_{high} > ~2.3
10	Enable	Active high enable	Input	-0.3 to 3.4 V_{low} < 0.95 V_{high} > 1.05

[1] CubeSense Sun can be configured for RS485 or UART

3 Mechanical Interface

This chapter describes the mechanical interface of the CubeSense Sun. This includes:

1. The outer dimensions of the CubeSense Sun,
2. The mounting definition and specifics (hole pattern and if the mounting of the component affects its performance),
3. Mass, Centre of Mass, and Inertia,
4. Coordinate System.

PLEASE NOTE: The dimensions given in this section are **indicative only**. The mechanical CAD files received from CubeSpace should be treated as the source of truth.

3.1 CubeSense Sun

The CubeSense Sun sensor is fully enclosed in a housing that also rigidly supports the lens. The aluminium housing is manufactured from aluminium 6082-T6 treated with a chromate conversion coating (Alodine).

3.1.1 Outer Dimensions

The overall dimensions of the CubeSense Sun are shown in Figure 1.

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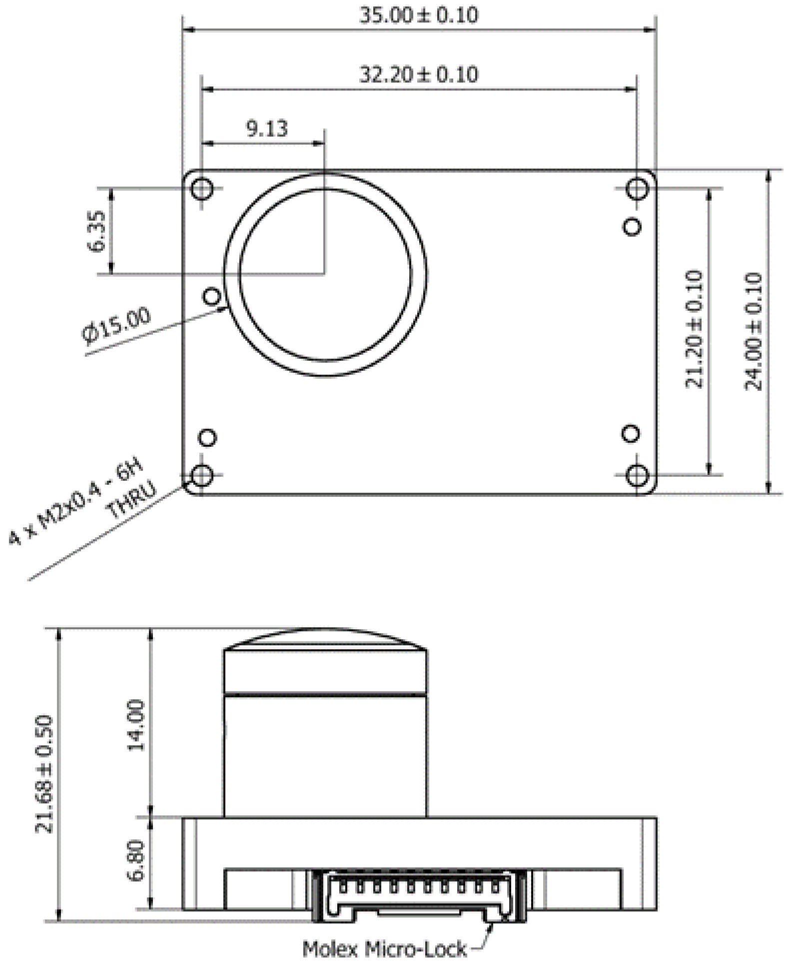

Figure 1: Indicative dimensions of the CubeSense Sun sensor

3.1.2 Mounting definition

The CubeSense Sun should be mounted on a satellite's side-panel by way of four (4) M2x0.4mm threaded mounting holes as noted in Figure 1. It is very important to ensure that the camera lens protrudes completely through the side panels of the satellite, as demonstrated in Figure 2.

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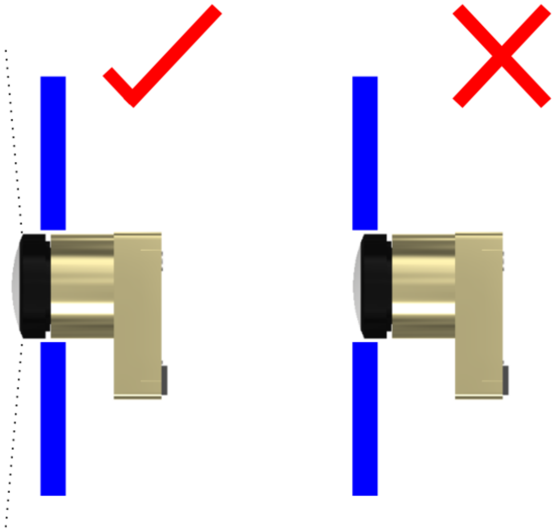

Figure 2: Correct and Incorrect Protruding Distance

If the lens does not protrude fully through the side panel, the sensor will detect reflections from the side panels. Best practice is to have the lens protrude as far as possible from the side panel. The CubeSense lens has a 200-degree FOV of which 180-degrees are evaluated for sun detection as shown inFigure 3.

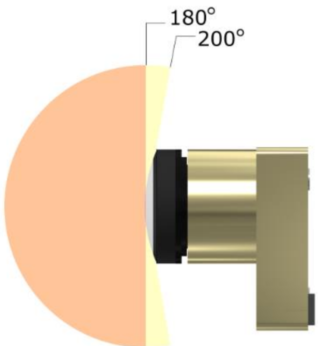

Figure 3: CubeSense FOV

Any reflective panels in the CubeSense FOV should/can be masked in software using the instructions provided in the User Manual (see [2]). The User Manual is typically only supplied to clients once an order has been placed.

3.1.3 Mass, COM and Inertia

The CubeSense Sun has a mass of 15.0 g ± 5 %. Figure 4 indicates the COM position.

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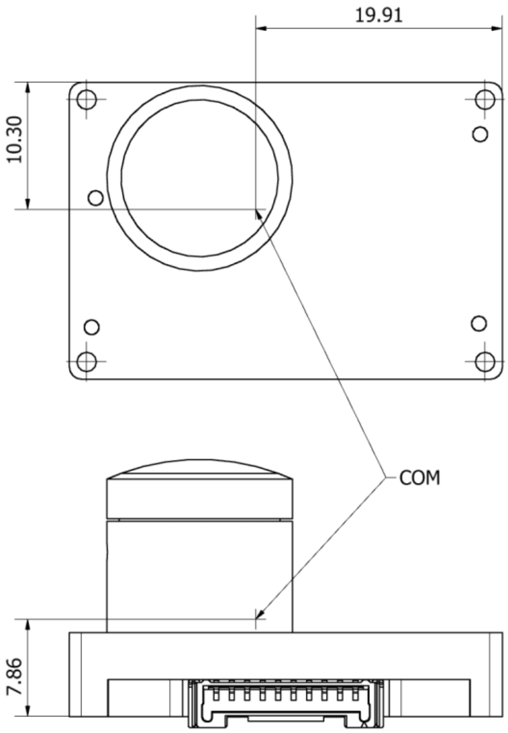

Figure 4: COM position of CubeSense Sun

The moments of inertia of the CubeSense Sun about the COM position are presented in Table 11, the axes reference for the inertias is shown in Figure 5.

Table 11: CubeSense Sun Moments of Inertia (MOI)

AXIS	VALUE
I_{xx} (gmm^2)	909 ± 10 %
I_{yy} (gmm^2)	980 ± 10 %
I_{zz} (gmm^2)	747 ± 10 %

3.1.4 Measurement Coordinate System Definition

The vector output used by the CubeSense Sun follows the axis definition shown in Figure 5.

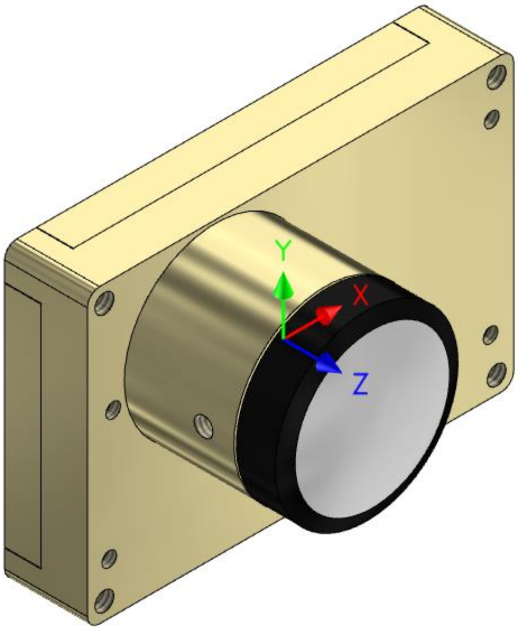

Figure 5: CubeSense Sun coordinate system definition

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4 CubeSense Sun Mass

Table 12 details the mass of the CubeSense Sun.

Table 12: CubeSense Sun mass

CUBESENSE SUN	VARIANT/MODEL	MASS (G)[2]	NOTES
CubeSense Sun	NA	15	Measured

[2] This is the mass of the CubeProduct only and does not include any harnessing as these lengths can vary. Allow margin for the harness mass (refer section 2.3).

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5 EMI / EMC

This chapter identifies all oscillators (potential RF emitters) used on the CubeSense Sun.

5.1 Potential RF emitter list

Table 13: CubeSense Sun Potential Emitters

COMPONENT	EMITTER TYPE	FREQUENCY	FREQ. STABILITY
MCU	Crystal	24 MHz	± 50 ppm
Comms UART	-	921.6 kHz	± 50 ppm
Internal I2C	-	100 kHz	± 50 ppm
Comms I2C	-	100 kHz	± 50 ppm
Comms CAN	-	500 kHz	± 50 ppm
Camera sensor	Crystal	24.576 MHz	± 20 ppm

5.2 Minimising EMI / EMC effects

5.2.1 Grounding

The enclosure and mechanical parts of CubeSense Sun are connected to the electrical ground through a filter designed to minimise EMI, as illustrated by Figure 6, with "ADCS node 1" representing the CubeSense Sun. (Note that a generic CubeADCS diagram is shown to explain the grounding strategy followed, for consideration by the client). The enclosures of the [CubeADCS core stack] and the CubeSense Sun can be grounded by the user if desired.

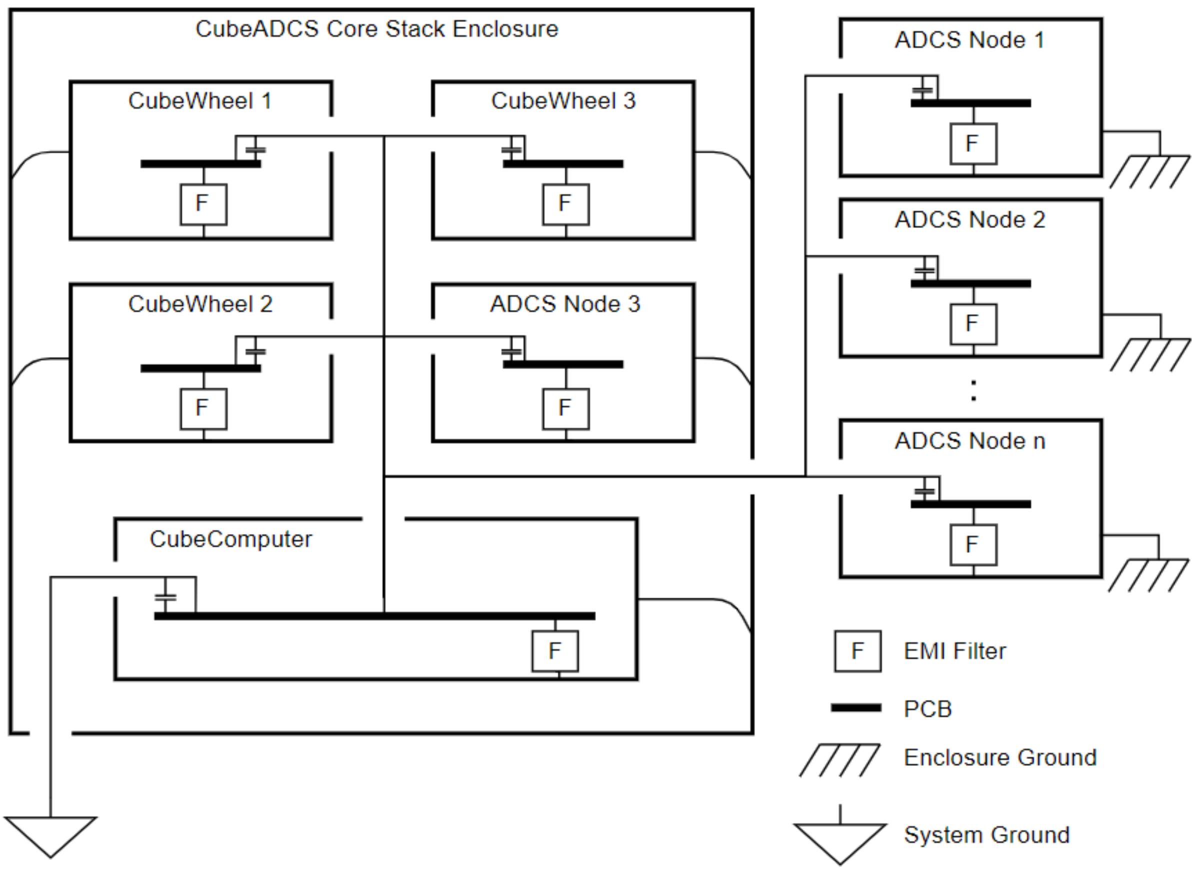

Figure 6: Generic Grounding diagram

The filter design consists of a high value resistor in parallel with a low ESL capacitor. This dissipates high frequency noise to ground and also conducts static buildup off of the enclosure. The commonly used alternative method where the enclosures are directly connected to the ground introduces the risk that shorts may occur during satellite integration.

In some cases a customer might require the enclosure of the CubeSense Sun to be completely isolated from the System Ground by removing the EMI filters completely. In such a case, it could be specified as a custom option when placing the order.

5.2.2 Shielding

Shielding of the CubeSense Sun electronics is accomplished by the mechanical (Faraday) enclosure. The enclosure makes contact to the chassis ground trace on each PCB. This chassis trace is connected to PCB ground through the filter discussed in the previous section.

5.2.3 Harness pairing of conductors and twisting.

The wires of the harnesses provided by CubeSpace for the CubeSense Sun form twisted pairs as indicated in Table 14 below.

Table 14: Twisted Wire Pairs on Harness

PIN 1	PIN 2	COMMENT
3V3	GND	
Enable	GND	
Boot	GND	
CANH	CANL	If CAN is used
RS485 A	RS485 B	If optional RS485 is used
UART Rx	GND	If UART is used
UART Tx	GND	If UART is used

Furthermore, the twisted wire pairs are braided/rolled to form the final harness. Figure 7 below shows an image of a final flight harness.

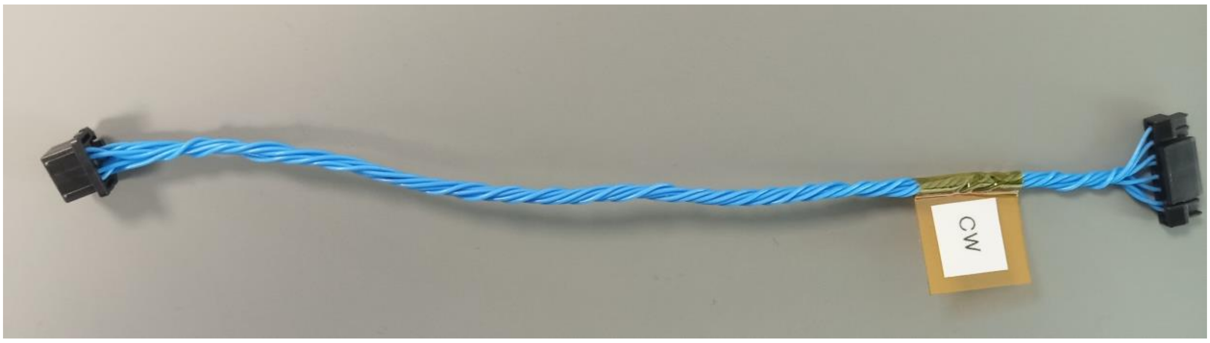

Figure 7: Flight harness example

5.2.4 Filtering and Suppression

The following noise filtering schemes are utilised on the CubeSense Sun:

a. All pins that are externally exposed through headers are filtered by way of 100pF decoupling to ground as shown in Figure 6.
b. LC filtering is done on the CubeComputer's external 5V and 3.3V power supply input lines.
    - For the standalone CubeSense Sun, the client is requested to consider implementing similar on the client ADCS / OBC side – details can be provided.
c. LC filtering is done on the CubeComputer's 5V and 3.3V supply lines to the various CubeProducts.
    - For the standalone CubeSense Sun, the client is requested to consider implementing similar on the client ADCS / OBC side – details can be provided.
d. Common-mode filtering is done on the CubeComputer's CAN communication interfaces (from the OBC, and to various CubeProducts).
    - For the standalone CubeSense Sun, the client is requested to consider implementing similar on the client ADCS / OBC side – details can be provided.
e. RC filtering is employed on the CAN, UART, and (optional) I2C communication interfaces to minimize spurious frequencies above 1 MHz.
f. The Boot- and Enable lines from the CubeComputer to the various CubeProducts employ LC filtering at the CubeConnect-level.
    - For the standalone CubeSense Sun, the client is requested to consider implementing similar on the client ADCS / OBC side – details can be provided.

5.2.4.1 Battery Power Rail Filtering

A pre-filter is in place for the satellite battery supply to the CubeComputer. This ensures that noise on this power rail will be minimized before entering the CubeADCS and will also reduce/minimized noise generated by the CubeADCS to be emitted onto the power rail.

For the standalone CubeSense Sun, the client is requested to consider implementing similar on the client ADCS / OBC side – details can be provided.

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6 Environmental Qualification

CubeSpace has recently completed a so-called “re-spin” of all generation 2 CubeProducts, including the CubeSense Sun. The re-spin effort entails minor design improvements across the board to improve lessons learnt during EMI/EMC characterisation sessions, to address minor layout optimisations that were identified and to address issues found on power regulation devices used on the CubeComputer whilst exposed to high TID radiation levels.

CubeSpace is currently in process of a full environmental re-qualification campaign of the re-spun versions of the generation 2 CubeProducts as they come of the production line. A completion date of mid 2023 is targeted. This chapter will then be updated accordingly documenting the formal qualification status of the CubeSense Sun.

6.1 Test approach outline

Environmental testing is done according to a “CubeSpace generation 2 Environmental Qualification plan”.

The mentioned qualification plan contains detailed information and steps to be taken by the typical test engineer when qualifying the CubeSense Sun, together with the applicable qualification test levels. In addition, derived from “CubeSpace generation 2 Environmental Qualification plan”, a detailed Environmental Test Procedure and Results document was created for the CubeSense Sun. The CubeSense Sun Environmental Test Procedure and Results document further detailed the exact procedure steps to be taken during a particular environmental test as well as the expected results that must be achieved to claim a qualification level “PASS” against a test.

The detailed test sequences are outside the scope of this document. Only the applicable qualification test levels are indicated in sub-sections below.

6.2 Thermal (Cold Start and Hot start) qualification testing.

The CubeSense Sun, while not powered, is subjected to a cold start temperature of -35 degC. Once the soak period of minimum 30minutes have passed, the CubeSense Sun is powered up and its start-up sequence is monitored for correct operation and if successful, a brief health check is done. The CubeSense Sun is then powered down and temperature raised to +70 degC and the power up sequence and brief heath check is repeated. The CubeSense Sun is again powered down and brought back to ambient temperature. A complete ATP is then conducted and if all tests pass, the CubeSense Sun is deemed to have passed its Thermal (Hot and Cold start) qualification test.

6.3 Thermal / Vacuum (TVAC) qualification testing

The components used in all CubeProducts are non-outgassing and are specifically chosen to fall within the CVCM < 0.1%, TML < 1% limits.

For every TVAC cycles (for both hot and cold extremes – see tables below) the CubeSense Sun is subjected to a full health check test procedure. Once all cycles have been completed, the CubeSense Sun is subjected to a full Acceptance Test Procedure. If the CubeSense Sun passes all tests, it is deemed to have passed TVAC testing at qualification levels.

Table 15: TVAC Hot cycle qualification levels

TVAC PARAMETER	TEST LEVEL
Chamber Pressure	1e-3 Pa or 1e-5 mBar

TVAC PARAMETER	TEST LEVEL
Number of Cycles	4
Dwell time after thermal stabilisation	1h
Temperature Tolerance	±2 °C
Temperature ramp rate	1 °C/min
Maximum Temperature (Qualification)	+80±2°C

Table 16: TVAC Cold cycle qualification levels

TVAC PARAMETER	TEST LEVEL
Chamber Pressure	1e-3 Pa or 1e-5 mBar
Number of Cycles	4
Dwell time after thermal stabilisation	1h
Temperature Tolerance	±2 °C
Temperature ramp rate	1 °C/min
Minimum Temperature (qualification)	-20±2°C

6.4 Vibration qualification testing

For each of the three axes of the CubeSense Sun, once a particular vibration type of test is done (see tables below), it is physically inspected for any damage and then subjected to a full health check test procedure. Once all vibration type tests have been completed the CubeSense Sun is subjected to a full Acceptance Test Procedure. If the CubeSense Sun passes all tests, it is deemed to have passed Vibration testing at qualification levels.

Table 17: Low level sine resonance search levels

FREQUENCY (HZ)	AMPLITUDE (G) [0-PK]
5	1
2000	1
Sweep rate	2 Oct/min

The **success criteria** for the resonance search are:

- Less than 5% change in the average frequency of peaks displayed by the accelerometer placed on the DUT.
- Less than 20% in amplitude shift

Table 18: Qualification sine plus quasi-static levels

FREQUENCY (HZ)	AMPLITUDE (G) [0-PK]
5	1
10	2.5
21	2.5
25	15

FREQUENCY (HZ)	AMPLITUDE (G) [0-PK]
30	15
35	3
110	3
125	0.25
Sweep rate	2 Oct/min

Table 19: -3dB random vibration qualification levels

FREQUENCY (HZ)	AMPLITUDE (G^2/HZ)
20	0.0282
50	0.0802
800	0.0802
2000	0.0130
Duration	60 seconds
Grms	10.02

Table 20: Random vibration qualification levels

FREQUENCY (HZ)	AMPLITUDE (G^2/HZ)
20	0.0563
50	0.1600
800	0.1600
2000	0.0260
Duration	120 seconds
Grms	14.16

6.5 Shock qualification testing

For each of the three axes of the CubeSense Sun, once a particular shock test is done (see table below), it is physically inspected for any damage and then subjected to a full health check test procedure. Once tests in all axes have been completed the CubeSense Sun is subjected to a full Acceptance Test Procedure. If the CubeSense Sun passes all tests, it is deemed to have passed Shock testing at qualification levels.

Table 21: Qualification shock test levels

FREQUENCY [HZ]	SHOCK SPECTRUM VALUES [G] - 3DB (LOWER-LEVEL THRESHOLD)	SHOCK SPECTRUM VALUES [G] (NOMINAL QUALIFICATION LEVELS)	SHOCK SPECTRUM VALUES [G] +6DB (UPPER-LEVEL THRESHOLD)
30	2	5	20
1000	750	1500	6000
10000	750	1500	6000

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6.6 Radiation

For the CubeSpace generation 2 product line, the minimum successful TID level is defined as 24 kRad at a 95% confidence level. (This is calculated for 3 units tested as: Rating = Mean – 3*STD)

6.7 EMI / EMC

As mentioned in this chapter's introduction only EMI / EMC characterisation sessions have taken place to date. No formal EMI / EMC testing has been done to date.

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7 Materials used.

A Declared Materials List document is available for the CubeSense Sun and is optionally available from CubeSpace and should be specifically requested during order placement.

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