CUBESPACE

# Interface Control Document

## CubeSense Sun CS M2.1E4.5

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# Revision History

| Version | Authors | Date | Description |
|---|---|---|---|
| 1.00 | C. Leibbrandt | 27/07/2023 | First release. |
| 1.01 | R. van Wyk | 14/09/2023 | Removed RS422 support. Default harnesses rewording. Formatting improvements. |
| 1.02 | A. Coetzee | 26/02/2025 | Common ICD changes implemented. New document number with M and E version numbers. Various improvements. Current draw values revised. |

# Reference Documents

The following documents are referenced in this document.

[RD1] CS-DEV.PD.CS-01 CubeSense Sun Product Description Ver.1.00 or later

[RD2] CS-DEV.UM.CS-01 CubeSense Sun User Manual Ver.1.03 or later

[RD3] CS-DEV.ETP.CA-01 Generic Environmental Test Plan Ver.1.05 or later

[RD4] CS-DEV.FRM.CA-01 CubeProduct Firmware Reference Manual Ver 7.02 or later

# List of Acronyms/Abbreviations

| | |
|---|---|
| ADCS | Attitude Determination and Control System |
| CAN | Controller Area Network |
| CoM | Centre of Mass |
| CS | CubeSense Sun |
| EHS | Earth Horizon Sensor |
| EM | Engineering Model |
| EMC | Electromagnetic Compatibility |
| EMI | Electromagnetic Interference |
| ESD | Electrostatic Discharge |
| FM | Flight Model |
| ICD | Interface Control Document |
| FSS | Fine Sun Sensor |
| I2C | Inter-Integrated Circuit |
| ID | Identification |
| MCU | Microcontroller Unit |
| MoI | Moment of Intertia |
| OBC | On-board Computer |
| PCB | Printed Circuit Board |
| RF | Radio Frequency |
| SRAM | Static Random-Access Memory |
| TC | Telecommand |
| TCTLM | Telecommand and Telemetry (protocol) |
| TLM | Telemetry |
| UART | Universal Asynchronous Receiver/Transmitter |

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# 1. Introduction

The purpose of this document is to provide information on how to correctly interface with CubeSense Sun. This includes communications, power requirements, mechanical mounting and axes definitions, as well as guidelines on EMI/EMC compatibility. It is assumed that the reader is already familiar with the relevant product description document [RD1]. Details regarding environmental qualification, and a declared materials list, are available to clients upon request.

**CubeSpace cannot guarantee nominal operation of CubeSense Sun if the specifications provided in this document are not adhered to.**

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

**Table 1: Document Applicability**

| Version | Notes |
|---|---|
| M2.1E4.5 | SurTec 650 conversion coating (silver) |
| M2.0E4.5 | Alodine conversion coating (gold) |

# 2. Electrical Interface

## 2.1 Communication Interfaces

### *2.1.1 CAN Characteristics*

**Table 2: CAN Bus Characteristics**

| Parameter | Value |
|---|---|
| Supported CAN standard | V2.0B |
| Supported bit rate | 1 Mbit/s |
| Supported protocols | CubeSpace CAN Protocol,<br>CubeSat Space Protocol (CSP) |
| Default CAN address | 4 (configurable) |
| CAN termination | 2 kΩ |

### *2.1.2 UART and RS485 Characteristics*

**Table 3: UART/RS485 Characteristics**

| Parameter | Value |
|---|---|
| Maximum supported baud rate | 921600 (configurable) |
| Data bits | 8 |
| Parity | None |
| Stop bits | 1 |
| RS485 address | 1 (configurable) |
| RS485 termination | 1 kΩ |

RS485 communication can be selected as a custom option and must be specified by the client when placing the order.

**When RS485 is selected, the UART interface will not be available.**

### *2.1.3 I2C Characteristics*

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 must support clock-stretching. The relevant I2C characteristics are given in Table 4.

**Table 4: I2C Characteristics**

| Parameter | Value |
|---|---|
| Maximum supported bit rate | 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 |

### *2.1.4 Boot Line*

CubeSense Sun implements a boot line for accessing the MCU's low-level ROM bootloader. The boot line must be pulled high prior to power-on to access the ROM bootloader. It is used by CubeSpace to initially flash the CubeSpace software bootloader to the MCU, thereafter the software bootloader is used for uploading flight software. The client can leave this pin unconnected, however it is recommended to connect it to the ADCS/OBC as a recovery method in case the software bootloader needs to be updated or re-flashed.

**Due to hardware restrictions, the software bootloader cannot be upgraded or re-flashed over RS485.**

## 2.2 Power Interface

Typical power consumption characteristics for CubeSense Sun are independent of satellite size or the ADCS mode being used.

**Table 5: Power Consumption: 3.3 V Line**

| Parameter | Value | Notes |
|---|---|---|
| Average current | 28 mA | Measured over a 1-second loop. |
| Average power | 93 mW | |
| Maximum current | 60 mA | |
| Maximum power | 200 mW | |
| Inrush current peak | 324 mA | Occurs when Enable line is pulled high. |
| Inrush current duration | ~1 ms | |

### *2.2.1 Enable Line*

CubeSense Sun implements an externally controlled enable line to power on the device. The enable line is active-high and should be controlled by the client ADCS/OBC.

### *2.2.2 3.3 V Power Switch*

CubeSense Sun implements an input power switch that is enabled by pulling the enable line high. The power switch also provides a current limit of 400 mA to protect against latch-up events. Under- and overvoltage protection is also implemented, with a range of 2.5 V – 3.9 V depending on thermal conditions.

### *2.2.3 Client ADCS/OBC Power Protection Requirements*

CubeADCS implements voltage and current monitoring on the 3.3 V line to ensure that the supply voltage is always within range and to mitigate the effects of latch-up in the event of a fault. If CubeSense Sun is not used as part of a CubeADCS bundle, it is recommended that the client ADCS/OBC implements the same protections.

### *2.2.4 Power and Signal Ground*

CubeSense Sun does not have separate power and signal ground, all circuits share the same ground.

## 2.3 Header Pinout and Electrical Characteristics

**Table 6: Header Details**

| Part | Description | Part Number |
|---|---|---|
| Header | Molex Micro-Lock Plus PCB Header | 5055671081 |
| Mating housing | Molex Micro-Lock Plus Receptacle Crimp Housing | 5055651001 |
| Housing terminal | Molex Micro-Lock Female Crimp Terminal | 5054311100 |

**Table 7: Header Pinout and Electrical Characteristics**

| Pin # | Pin Name | Pin Description | IO Type | Voltage Range [V] |
|---|---|---|---|---|
| 1 | Boot | Toggle ROM bootloader on startup<br>Active-high<br>Leave disconnected if unused | Input | 0 to 3.4 |
| 2 | I2C SDA | I2C data line | Bidirectional | 0 to 3.4 |
| 3 | 3V3 | Supply voltage | Power | 3.2 to 3.4 |
| 4 | UART Tx | UART data transmit line (default) | Output | 0 to 3.4 |
| | RS485 A | RS485 A (alternative) | Bidirectional | |
| 5 | CAN P | High level CAN bus line | Bidirectional | 0 to 3.4 |
| 6 | CAN N | Low level CAN bus line | Bidirectional | 0 to 3.4 |
| 7 | UART Rx | UART data receive line (default) | Input | 0 to 3.4 |
| | RS485 B | RS485 B (alternative) | Bidirectional | |
| 8 | GND | Power and signal ground | Power | 0 |
| 9 | I2C SCL | I2C Clock line | Bidirectional | 0 to 3.4 |
| 10 | Enable | Toggle power on<br>Active-high | Input | 0 to 3.4 |

## 2.4 Harness Details

A standalone CubeSense Sun will ship with two harnesses: an EM harness as part of the ground support equipment package to allow for immediate testing and health checks, and a standard FM pigtail harness that can be used by the client to assemble a flight harness. The standard FM pigtail harness specifications are described in

Table 8. The standard length can be cut shorter, and longer (custom) lengths can be arranged during order placement.

**The EM harness is provided as part of the ground support equipment package only and is not low-outgassing. Therefore, it is not safe for flight or for use in a vacuum.**

**Table 8: Harness Details**

| Harness | Std. Length [mm] | Wire Mass [g/m] | No. Wires | Wire Gauge [AWG] | Housing Mass [mg] | Terminal Mass [mg] | Total[1] Mass [g] |
|---|---|---|---|---|---|---|---|
| FM pigtail | 400 | 1.96 | 10 | 26 | 198.8 | 35.434 | 8.4 |

[1] Weight of supplied pigtail harness only, excludes ADCS/OBC mating parts.

# 3. Mechanical Interface

CubeSense Sun is fully enclosed in an aluminium enclosure (6082-T6), treated with a chromate conversion coating.

**The dimensions given in this chapter are indicative only. The mechanical CAD files with the latest dimensions are supplied to customers and must be used for final design and fitment verification.**

## 3.1 Outer Dimensions

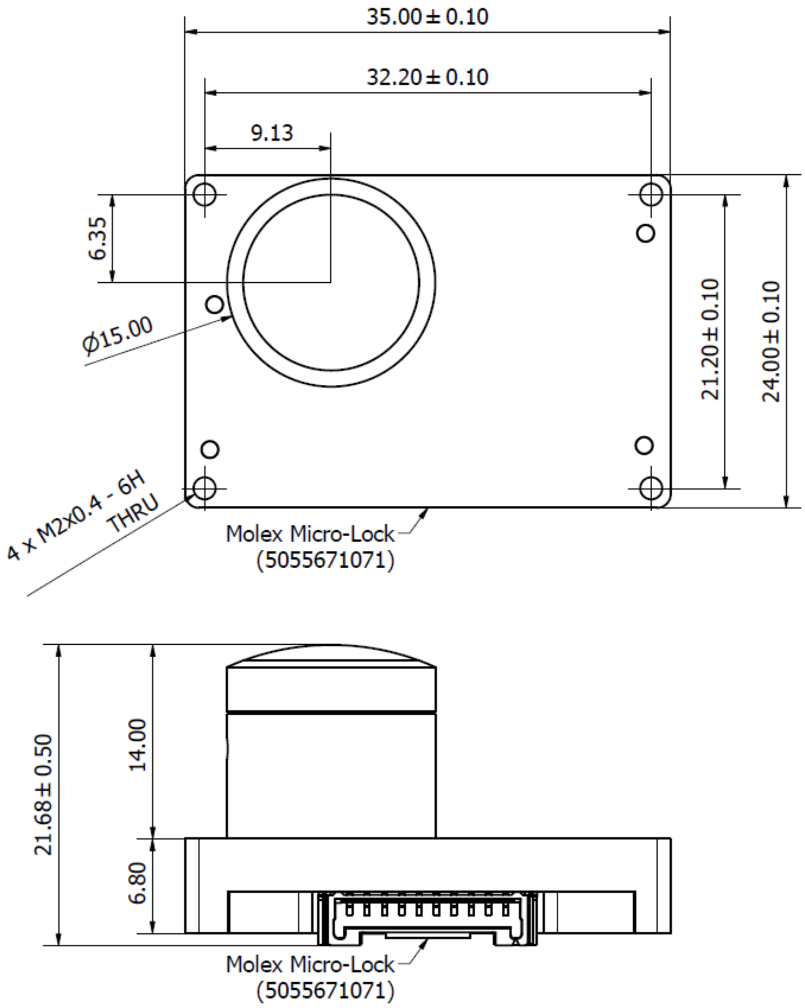


**Figure 1: Indicative Outer Dimensions**

## 3.2 Mounting Definition

CubeSense Sun should be panel-mounted by means of four (4) M2x0.4mm threaded mounting holes, as shown in Figure 1. Detections can be made up to 90° offset from boresight, making it essential to ensure that the lens protrudes fully through the mounting panel of the satellite, as illustrated in Figure 2.

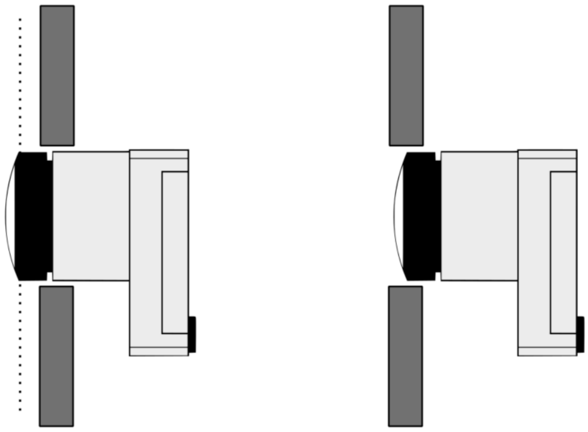

**Figure 2: Correct (Left) and Incorrect (Right) Protruding Distance**

If the lens does not fully protrude through the panel, then the sensor may falsely detect reflections on the panel. The best practice is to have the lens protrude as far as possible though the panel.

Any reflective panels in the FoV should be masked in software using the instructions provided in the User Manual [RD2].

## 3.3 Mass, CoM and Inertia

CubeSense Sun has a mass of 15.0 g ± 5 % (excluding harness). The centre of mass is located as shown in Figure 3 below.

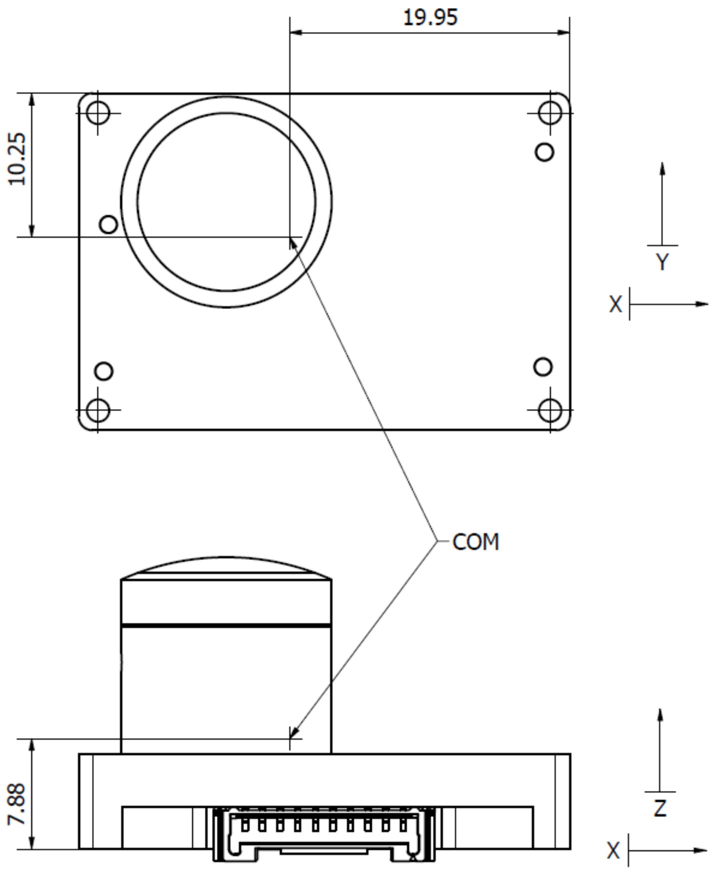


**Figure 3: CoM Position**

The moments of inertia (MoI) of CubeSense Sun about its CoM are presented in Table 9, the axes reference for the inertias is shown in Figure 3.

**Table 9: Moments of Inertia**

| Moment Axis | Value [gmm²] |
|---|---|
| $I_{xx}$ | 955 ± 10 % |
| $I_{yy}$ | 904 ± 10 % |
| $I_{zz}$ | 720 ± 10 % |

# 4. Software Interface

Each CubeProduct is accompanied by a user manual [RD2] that provides details regarding telemetry exchanges using ground support equipment. For further information regarding software interfacing and control, please refer to the firmware reference manual [RD4].

# 5. Measurement Coordinate System Definition

The measurement coordinate system is defined as the reference coordinate system for detections made by CubeSense Sun. The origin and axes definitions for the measurement coordinate system are indicated in Figure 4.

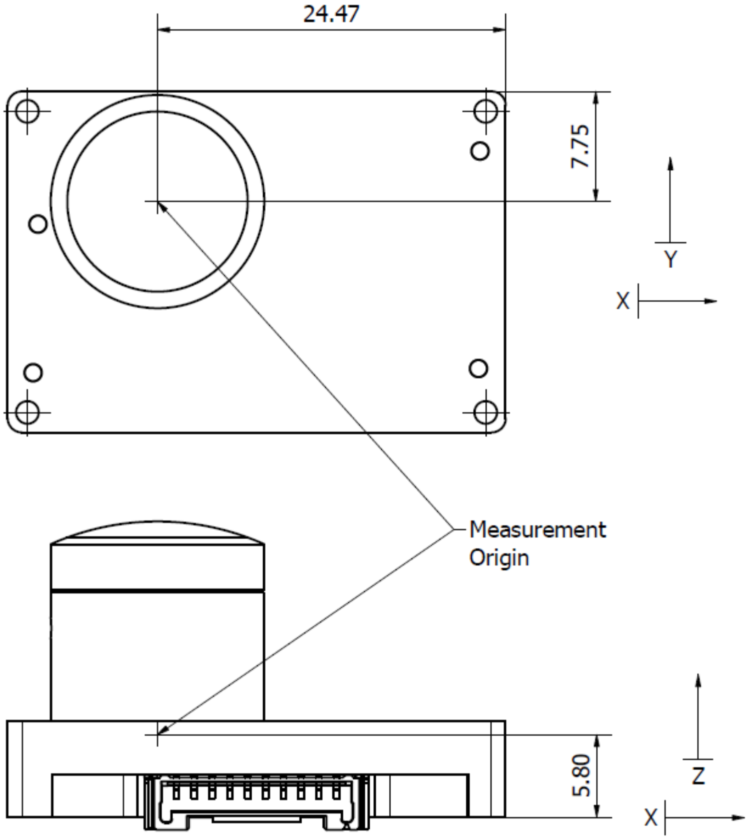


**Figure 4: Measurement Coordinate System**

# 6. EMI/EMC

## 6.1 Potential RF Emitters

Table 10 below lists all oscillator clock sources contained in CubeSense Sun. All other clocks and data rates are derived (multiples or divisions) from these sources.

**Table 10: Potential RF Emitters**

| Source | Frequency [MHz] | Frequency Stability [ppm] |
|---|---|---|
| MCU clock | 24 | ± 50 |
| Image sensor clock | 24.576 | ± 20 |

## 6.2 EMI/EMC Cleanliness

### *6.2.1 Grounding*

The enclosure and mechanical parts of CubeSense Sun are connected to the power and signal ground through a filter designed to minimise EMI, as illustrated in Figure 5. The enclosure of CubeSense Sun can be grounded by the user if desired.

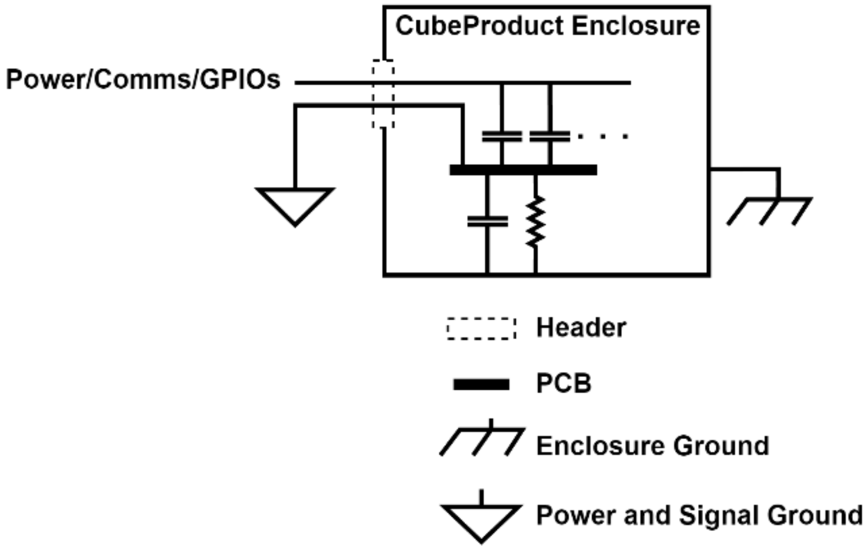


**Figure 5: Enclosure Grounding**

The enclosure's RC 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 away from the enclosure. The commonly used alternative method where the enclosure is directly connected to the ground introduces the risk that a short circuit could occur during satellite integration.

In some cases a customer might require the enclosure of CubeSense Sun to be completely isolated from the system ground by removing the EMI filters completely. In such a case, it should be specified as a custom option during order placement.

### *6.2.2 Shielding*

Shielding of CubeSense Sun electronics is accomplished by the mechanical enclosure as a Faraday cage. The enclosure makes contact to the chassis ground trace on each PCB. This chassis trace is connected to the PCB power and signal ground through the filter discussed in Section 6.2.1.

### *6.2.3 Filtering and Suppression*

The following noise filtering strategies are implemented on CubeSense Sun:

- All pins that are externally exposed through headers are filtered by way of 100 pF decoupling capacitors to power and signal ground as shown in Section 6.2.1.
- RC filtering is applied on the CAN and UART communication interfaces to minimize spurious frequencies above 1 MHz.

The following noise filtering strategies are recommended for consideration on the client ADCS/OBC side:

- LC filtering on the 3.3 V supply and the boot- and enable lines to CubeSense Sun.
- Common-mode filtering on the CAN communication interface to CubeSense Sun.