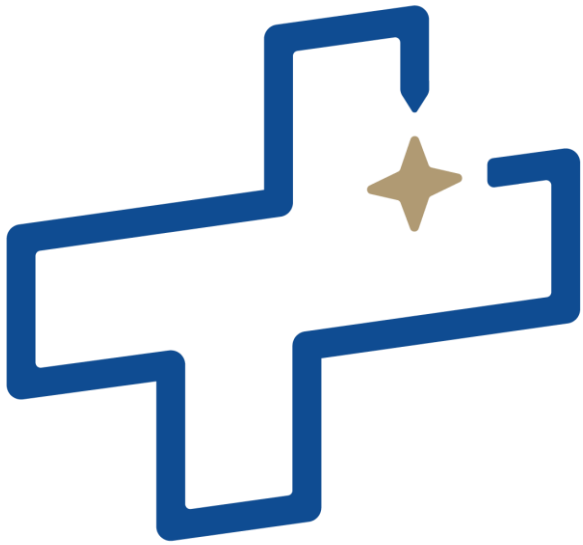




CUBESPACE

Interface Control Document CubeSense Earth CI M2.1E1.3

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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.CI-01	CubeSense Earth Product Description Ver.1.01 or later
[RD2]	CS-DEV.UM.CI-01	CubeSense Earth User Manual Ver.1.02 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
CI	CubeSense Earth
CoM	Centre of Mass
EHS	Earth Horizon Sensor
EM	Engineering Model
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
FoV	Field of View
FM	Flight Model
FSS	Fine Sun Sensor
I2C	Inter-Integrated Circuit
ICD	Interface Control Document
ID	Identification
MCU	Microcontroller Unit
Mol	Moment of Inertia
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 Earth. 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 Earth if the specifications provided in this document are not adhered to.

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

Table 1: Document Applicability

Version	Notes
M2.1E1.3	SurTec 650 conversion coating (silver)
M2.0E1.3	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, CubeSat Space Protocol (CSP)
Default CAN address	4 (configurable)
CAN termination	2 k Ω

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 k Ω

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 Earth 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 Earth must support clock stretching. The relevant I2C characteristics for the CubeSense Earth 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 Earth 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 Earth are independent of satellite size or the ADCS mode being used.

Table 5: Power Consumption: 3.3 V Line

Parameter	Value	Notes
Average current	38 mA	Measured over a 1-second loop.
Average power	126 mW	
Maximum current	46 mA	
Maximum power	152 mW	
Inrush current peak	266 mA	Occurs at jump to control program from software bootloader.
Inrush current duration	~1 ms	

2.2.1 Enable Line

CubeSense Earth 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 Earth 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 Earth 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 Earth 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 Active-high 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 Active-high	Input	0 to 3.4



2.4 Harness Details

A standalone CubeSense Earth 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]	No. Wires	Wire Mass [g/m]	Wire Gauge [AWG]	Housing Mass [mg]	Terminal Mass [mg]	Total Mass [g]
FM pigtail	400	10	1.96	26	198.8	35.434	8.4

¹ This is the weight of the supplied pigtail harness only and therefore excludes the chosen ADCS/OBC mating parts.



3. Mechanical Interface

CubeSense Earth 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

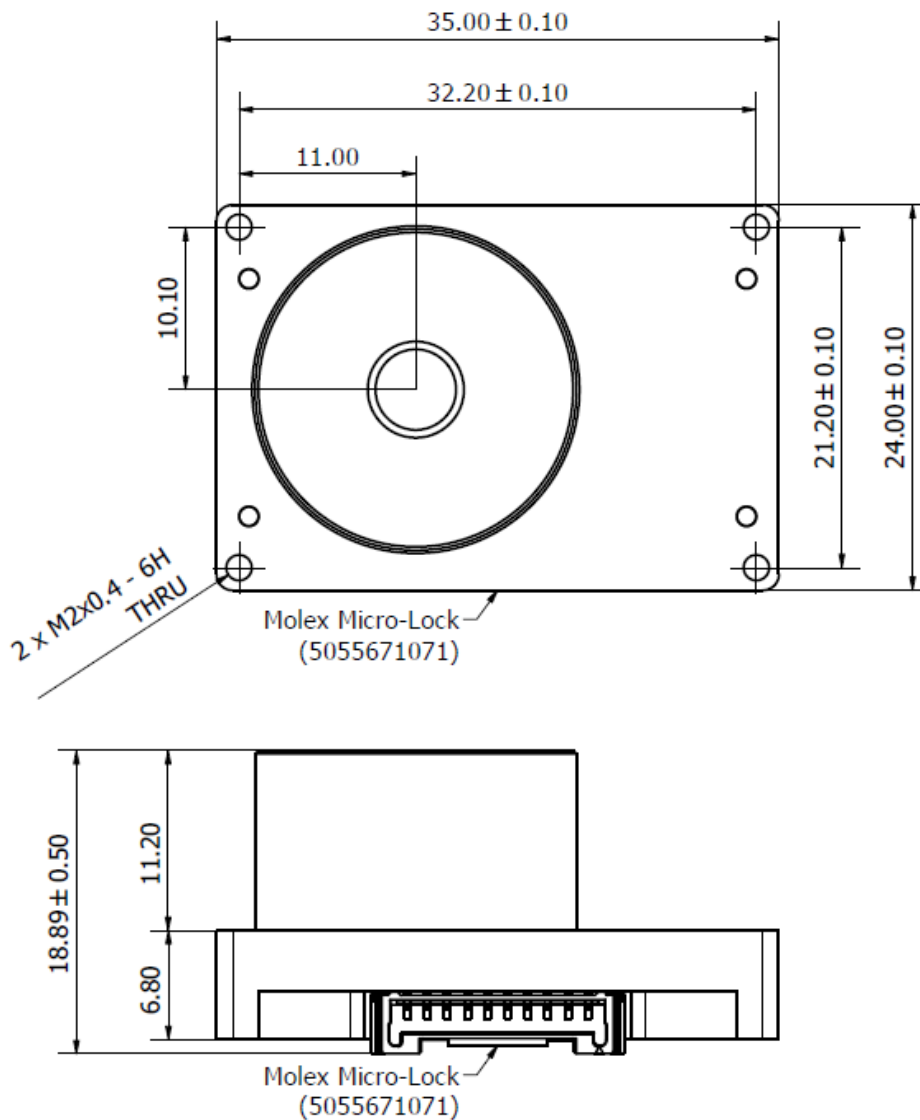


Figure 1: Indicative Outer Dimensions



3.2 Mounting Definition

CubeSense Earth should be mounted such that the Earth's horizon passes straight through the center of the FoV for the satellite's nominal flight orientation. This will allow for successful detections to be made at higher elevation angle offsets (while manoeuvres are being performed).

The maximum FoV in which detections are possible, is 90° horizontal and 80° vertical. The exclusion FoV, which should be kept clear of obstructions, is the defined by the FoV of the lens, which is 120° horizontal and 90° vertical.

3.3 Mass, CoM and Inertia

CubeSense Earth has a mass of 18.0 g $\pm$ 5 % (excluding a harness). Figure 2 displays the CoM position.

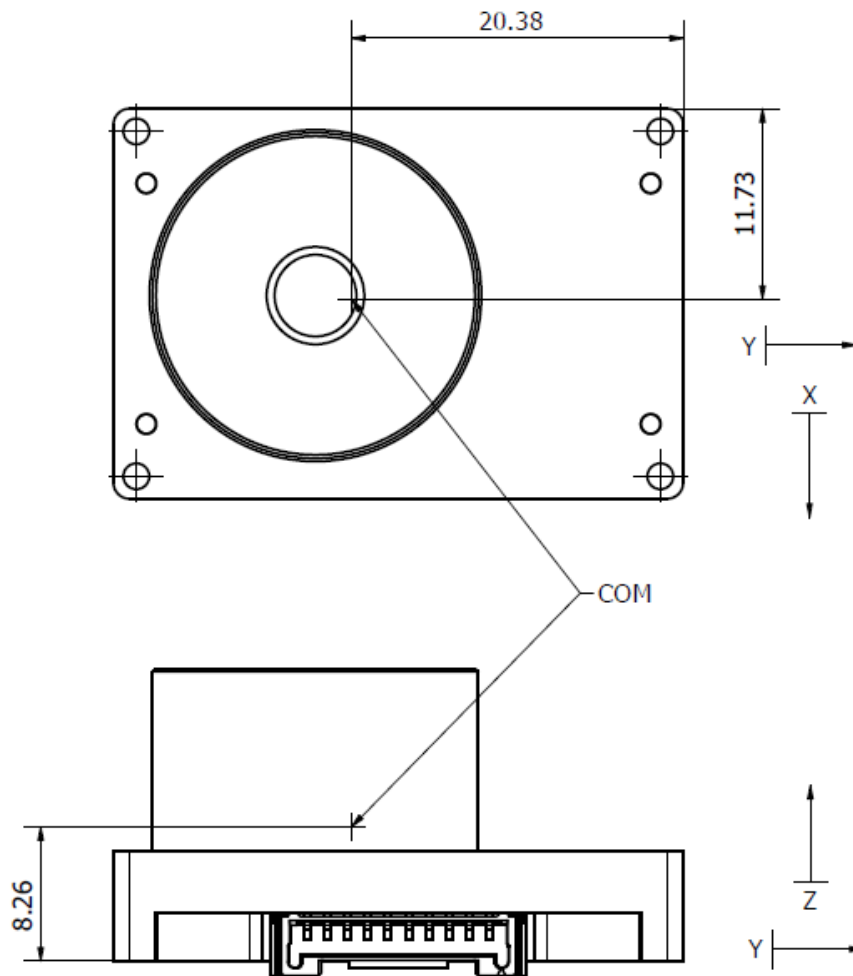


Figure 2: CoM Position

The moments of inertia (Mol) of CubeSense Earth about its CoM are presented in Table 9, using the coordinate system definition shown in Figure 2.

Table 9: Moments of Inertia

Moment Axis	Value [gmm ²]
I_{xx}	1081 $\pm$ 10 %
I_{yy}	852 $\pm$ 10 %
I_{zz}	1000 $\pm$ 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 Earth. The origin and axes definitions for the measurement coordinate system are indicated in Figure 3.

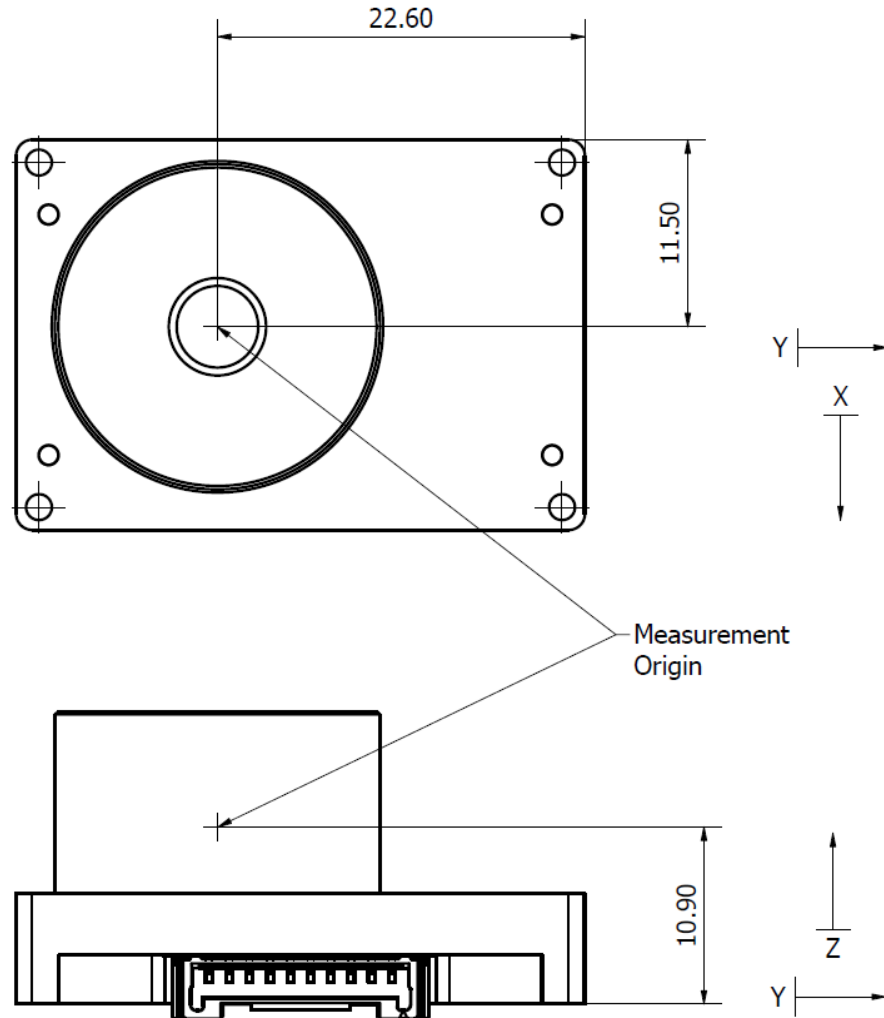


Figure 3: Measurement Coordinate System Definition



6. EMI/EMC

6.1 Potential RF Emitters

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

Table 10: Potential RF Emitters

Component	Frequency [MHz]	Frequency Stability [ppm]
MCU clock	24	± 50
Image sensor clock	5	-

6.2 EMI/EMC Cleanliness

6.2.1 Grounding

The enclosure and mechanical parts of CubeSense Earth are connected to the power and signal ground through a filter designed to minimise EMI, as illustrated in Figure 4. The enclosure of CubeSense Earth can be grounded by the user if desired.

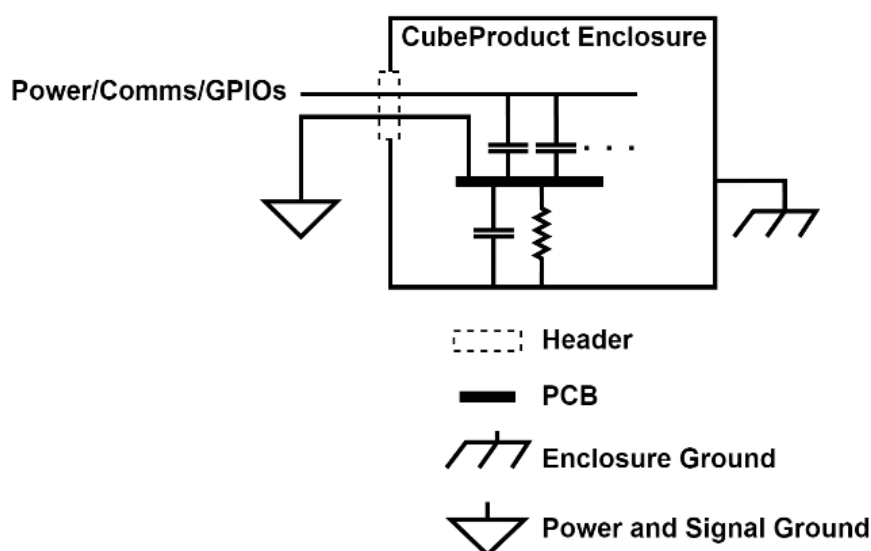


Figure 4: Enclosure Grounding

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 Earth 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 Earth 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 Earth:

- 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 Earth.
- Common-mode filtering on the CAN communication interface to CubeSense Earth.