CUBESPACE

CubeMag Generation 2

Interface Control Document (ICD)

DOCUMENT NUMBER	CS-DEV.ICD.CM-01
VERSION	1.02
DATE	09/11/2023
PREPARED BY	C. LEIBBRANDT
REVIEWED BY	J.M
APPROVED BY	W. Morgan
DISTRIBUTION LIST	External

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

Revision History

VERSION	AUTHORS	DATE	DESCRIPTION
A	C. Leibbrandt	24/05/2023	First draft release
B	C. Leibbrandt	25/07/2023	Updated based on review comments
1.00	C. Leibbrandt	27/07/2023	First published release
1.01	J.Miller	07/08/2023	Update to cover page and Harnessing
1.02	J.Miller	09/11/2023	Update to CAD Dimensions

Reference Documents

The following documents are referenced in this document.

[1]   CS-DEV.PD.CM-01   CubeMag Product Description Ver.1.00 or later

[2]   CS-DEV.UM.CM-01   CubeMag User Manual Ver.1.00 or later

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 2 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

List of Acronyms/Abbreviations

ACP	ADCS Control Program
ADCS	Attitude Determination and Control System
CAN	Controller Area Network
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

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 3 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

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

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 4 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

Table of Contents

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 5 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

Table of Tables

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 6 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

Table of Figures

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 7 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

1 Introduction

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

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

Table 1: Document Applicability

CubeProduct	Version	Notes
CubeMag Deployable	M2.1E4.2	
CubeMag Compact	M2.0E4.3	

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 8 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

2 Electrical Interface

This chapter describes the electrical interfaces of the CubeMag. This includes:

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

2.1 CubeMag Communication interface(s)

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

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

2.1.1 CAN Characteristics

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

Table 2: CAN bus characteristics for CubeMag.

PARAMETER	VALUE
Default Address	0x11 (configurable)
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 CubeMag UART interface are given in Table 3.

Table 3: UART characteristics for CubeMag

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 CubeMag 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

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 9 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

Table 4: RS485 / RS422 characteristics for CubeMag

PARAMETER	VALUE
Data Enable (DE) polarity	High

2.1.4   I2C Characteristics (custom option)

I2C communication with the CubeMag is provided as a custom option for the CubeMag Compact only and must specifically be specified by the client at the time of order placement. The CubeMag 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 CubeMag must support clock stretching. The relevant I2C characteristics for the CubeMag are given in Table 5.

Table 5: I2C bus characteristics for CubeMag

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   CubeMag Power supply

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

Table 6: CubeMag external power supply requirements

EXTERNAL POWER	CUBEMAG DEPLOYABLE	CUBEMAG COMPACT
Supply voltage [V]	3.3	
Peak power [mW]	230	
Average power [mW]	50	50
Deployment power [mW]	2350	N/A

2.2.1   Power consumption: 3.3V rail

The CubeMag 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 CubeMag are shown in Table 7.

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 10 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

Table 7: CubeMag Average power consumption and inrush current on 3.3 V line (no actuation)

SUBSYSTEM	3.3 V RAIL					NOTES
	Avg Current (mA)	Avg Power (mW)	Max Current (mA)	Max Power (mW)	Inrush (mA – µs)	
CubeMag Deployable	15	50	70	230	230-100	Excluding deployment current.
CubeMag Compact	15	50	70	230	230-100	

2.2.2   Power Protection

CubeMag Compact Power Protection is included. Specifically, if the 3V3 power supplied externally falls outside the 2.5V – 4.0V range, the CubeMag Compact will automatically switch off.

The CubeMag Deployable does not have over voltage protection and thus is susceptible to over voltage on the 3V3 power supply.

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

2.2.2.1   CubeMag Enable line.

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

2.2.2.2   CubeMag 3V3 undervoltage protection needed.

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 CubeMag. This will ensure protection of the CubeMag from undervoltage conditions and helps protect memory and other sensitive circuits on the CubeMag.

It is suggested that the client ADCS / OBC should provide current limiting for the 3V3 power supply to the CubeMag 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 CubeMag is connected to the client ADCS / OBC, similar protection is suggested.

2.2.2.3   CubeMag 3V3 power switch

The CubeMag implements an input power switch. It is enabled by pulling the Enable line high for the CubeMag. This switch allows the client ADCS / OBC to isolate it from the 3V3 power rail. The CubeMag power switch also provides a current limit (400mA)[1] feature to protect against hard-latch up events. The CubeMag Compact has overvoltage protection set to trigger upwards of 3.9V.

2.3   Harnesses

The CubeMag Compact is designed to connect to the CubeADCS via a dedicated harness with Molex Micro-Lock plus housings crimped on to each end.

---

[1] The deployable CubeMag current limit is set to 900mA to accommodate the deployment current.

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 11 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

The CubeMag Deployable is designed to connect to the CubeADCS via a dedicated inline harness with Molex Micro-Lock plus housings crimped on one end and a latched Harwin connector on the side interfacing with the CubeMag.

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 CubeMag is placed.

If the client does not use the CubeADCS, a single-sided harness will be provided. The client is required to provide the connector to their ADCS/OBC. CubeSpace tries to focus on mass production of harnesses with a limited number of connector housings supported to ensure reliability and repeatability. "Custom" / non-standard CubeSpace connectors are avoided.

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

The CubeMag standard harness characteristics are described in Table 8 below. In Table 8, Housing 1 and terminal 1 mates with the CubeADCS, and Housing 2 and terminal 2 mates with the CubeMag itself.

Table 8: CubeMag 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[2] Mass
CubeMag Sensor	229.64	35.434	26	1.96	198.8	35.434	8	

2.3.1 CubeMag Sensor Header on client ADCS / OBC

The client will be provided with a single-sided harness terminated with Molex Micro-Lock Plus single row 10 pin header (Molex 5055671081) to interface with the CubeMag Compact or a 6 pin HARWIN M80-8120605 connector in the case of a CubeMag Deployable. The harness will be manufactured to the client's specified length. The pinout of the supplied harness can be seen in Table 9 and Table 10. Note that the CubeMag deployable will have a harness of 6 pins and not 10.

2.3.2 Harness Header on CubeMag Deployable

The CubeMag deployable is supplied with a 50mm harness soldered into the CubeMag deployable PCB as shown in Figure 1. The connector on this harness is a 6 pin HARWIN M80-1030698S. A second inline

---

[2] 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.

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 12 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

harness is used to connect this harness to the CubeComputer (or client ADCS / OBC) sub-system (Figure

14).

Figure 1: CubeMag with 50mm Loom

Table 9: CubeMag deployable interface details

CUBEMAG DEPLOYABLE INTERFACE DETAILS				
Header Type:	HARWIN: M80-1030698S			
Number of pins	6			
Mating Housing	HARWIN: M80-8120605			
Housing Terminal	HARWIN: M80-0410005			
CubeMag Deployable Header pin definitions				
Pin #	Pin Name	Pin Description	IO Type	Voltage range [V]
1	Enable	Active high enable	Input	-0.3 to 3.4 $V_{low} < 0.95$ $V_{high} > 1.05$
2	3V3	Supply voltage for the digital electronics	Power	3.2 to 3.4
3	CAN_P (RS485A)[1] (UART_TX)	High level CAN bus line	Differential	-3.4 to 3.4
4	GND	Power ground of electronics	Power	0
5	BOOT	Active High boot line. Leave unconnected if unused.	Input	-0.3 to 3.4 $V_{low} < 0.5$ $V_{high} > 2.6$
6	CAN_N (RS485B) (UART_RX)	Low level CAN bus line	Differential	-3.4 to 3.4

[1]CubeMag Deployable must be configured for either CAN, RS485/RS422 or UART.

2.3.3 Harness Header on CubeMag Compact

A 10 pin Molex 5055671081 right angle header provides the electrical interface to the CubeMag Compact (See Figure 15).

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 13 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

Table 10: CubeMag Compact interface details

CUBEMAG COMPACT INTERFACE DETAILS				
Header Type:	Molex 5055671081			
Number of pins	10			
Mating Housing	Molex 5055651001			
Housing Terminal	5037650098			
CubeMag Compact 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
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 $V_{low} < {\sim}0.4$ $V_{high} > {\sim}2.3$
10	Enable	Active high enable	Input	-0.3 to 3.4 $V_{low} < 0.95$ $V_{high} > 1.05$

[1]CubeMag Compact can be configured for RS485 or UART

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 14 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

3 Mechanical Interface

This chapter describes the mechanical interface of the CubeMag. This includes:

1. The outer dimensions of the CubeMag,
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 CubeMag Deployable

The CubeMag Deployable consists of a base which is mounted on the outside of the satellite, an arm which deploys to 90 degrees when released, and a wire hold-down-and-release mechanism. The CubeMag Deployable has a primary magnetometer in the head of the deployment arm, and a secondary magnetometer on the base. The housing that encloses the magnetometer is manufactured from 6082-T6 aluminium.

3.1.1 Outer Dimensions

The overall dimensions of the CubeMag deployable in its stowed state are shown in Figure 2.
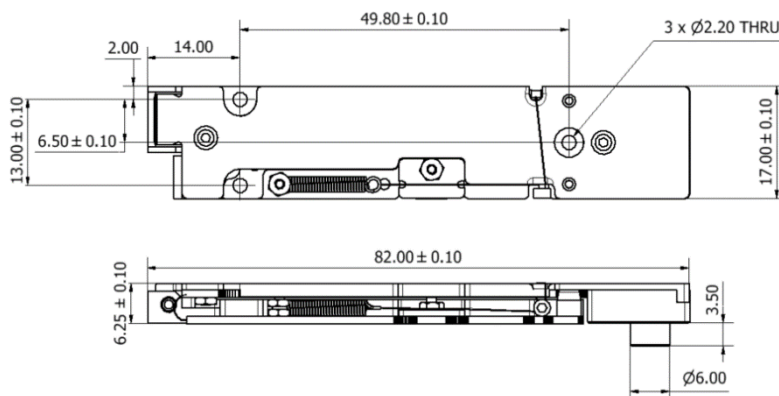
Figure 2: Indicative dimensions of CubeMag Deployable in the stowed state

Figure 3 displays the dimensions of the deployable magnetometer in the deployed state.

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 15 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External
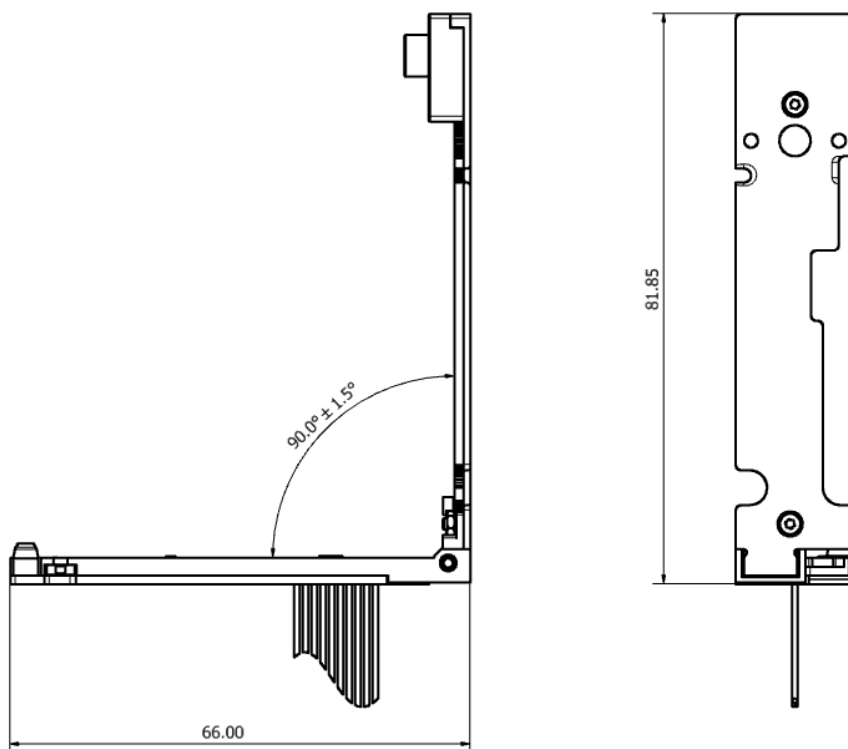
Figure 3: Indicative dimensions of CubeMag Deployable in the deployed state

3.1.2 Mounting definition

The deployable magnetometer is designed to mount to an external surface of the satellite. The magnetometer should not be placed in close proximity of any part of the satellite that may cause significant disturbances. See [1] for more details.

The hole placement and panel cut-outs required for mounting of the magnetometer are shown in Figure 4. The dashed line in Figure 4 represents the area the magnetometer will occupy, when in the stowed state, and must not be impinged upon.

Mounting of the deployable magnetometer is performed by way of three (3) non-ferrous M2 screws (refer to Figure 4 for screw hole locations) that pass through the magnetometer and thread into the panel onto which the magnetometer is mounted. Alternatively, the screws may pass through both the magnetometer and mounting panel and then secured with nuts on the inside of the panel.

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 16 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External
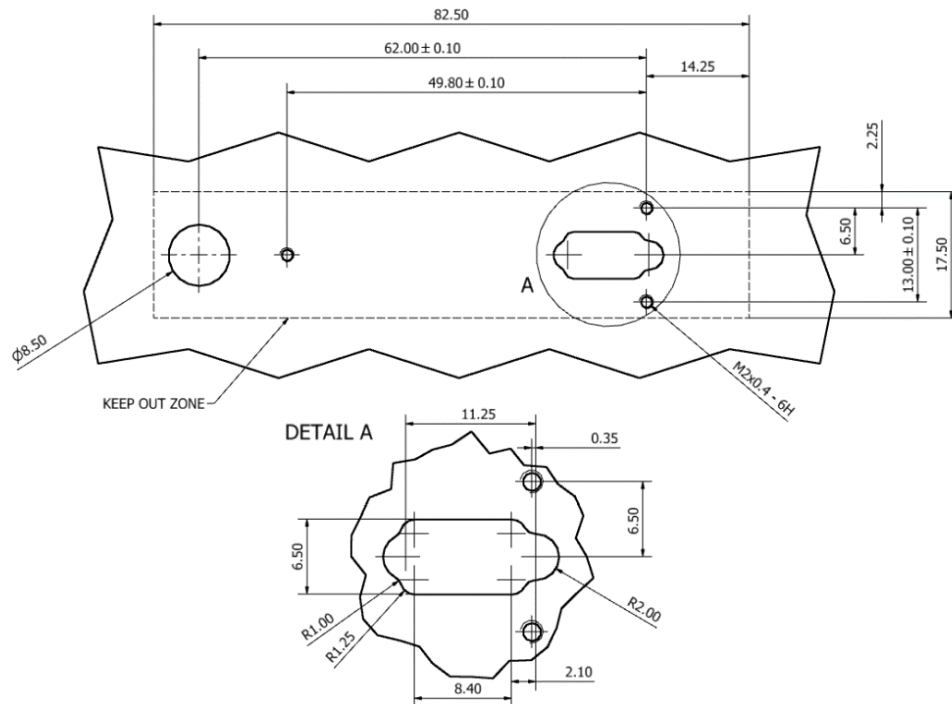
Figure 4: Panel cut-outs required to mount CubeMag Deployable

3.1.3   Mass, COM and Inertia

The total mass of the deployable magnetometer including its harness is 15.5 g ± 5 %. The COM position (excluding wire harness) of the deployable magnetometer when in the stowed position is shown in Figure 5.
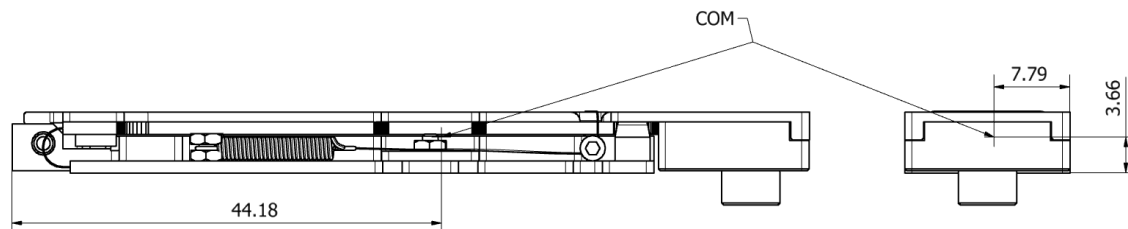
Figure 5: COM position of CubeMag deployable in the stowed state

Figure 6 displays the COM position of the CubeMag deployable (excluding wire harness) in the deployed state.

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 17 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External
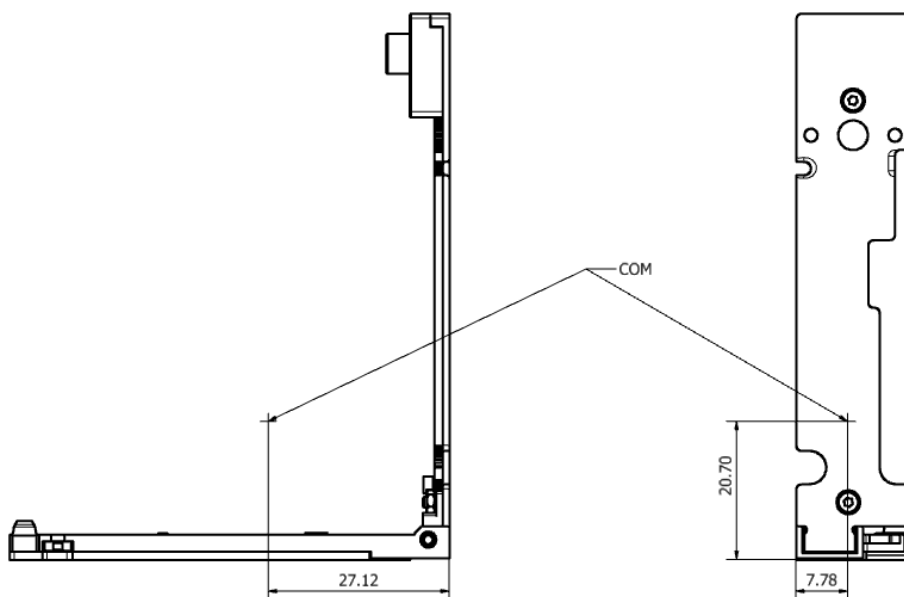
Figure 6: COM position of CubeMag deployable in the deployed state

The moments of inertia of CubeMag deployable in both stowed and deployed states, excluding any wire harness, about their respective COM positions are presented in Table 11, the axes reference for the inertias provided is shown in Figure 7.

Table 11: CubeMag deployable moments of inertia

	STOWED STATE	DEPLOYED STATE
I_{xx} (gmm²)	316 ± 10 %	12810 ± 10 %
I_{yy} (gmm²)	8310 ± 10 %	11800 ± 10 %
I_{zz} (gmm²)	8070 ± 10 %	23880 ± 10 %
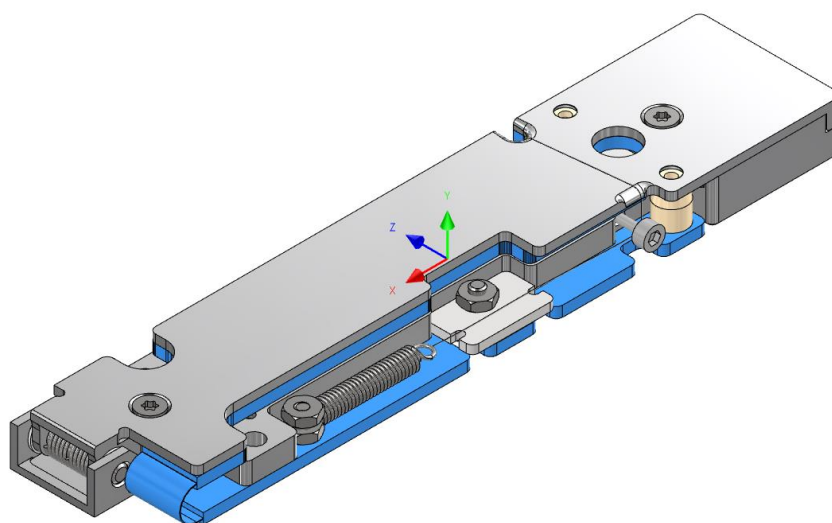
Figure 7: CubeMag deployable inertial reference frame

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 18 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

3.1.4   Measurement Coordinate System Definition

The CubeMag Deployable returns the magnetic field as a calibrated measurement[3] via telemetry. This calibrated measurement reference frame is the same for both the primary and secondary magnetometer and is deemed the coordinate system definition of the CubeMag deployable. The reference frame for the primary magnetometer is also the same whether the magnetometer is stowed or deployed. To achieve this, the magnetometer automatically senses whether it is deployed or not and transforms the measurements accordingly.
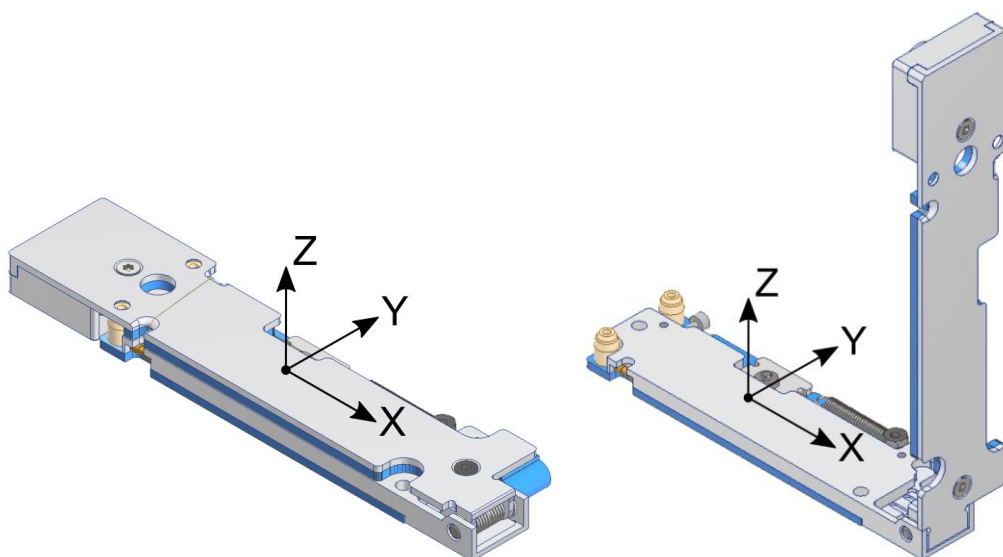
Figure 8: CubeMag deployable coordinate reference frame

3.2   CubeMag Compact

A CubeADCS bundle can optionally be upgraded with a compact, secondary (redundant) magnetometer. This magnetometer is fully enclosed within an aluminium housing (6082-T6) treated with a chromate conversion coating (Alodine), as shown in Figure 11.

3.2.1   Outer Dimensions

The overall dimensions of the CubeMag Compact are shown in Figure 9.

---

[3] The CubeMag has a Telemetry Message (TLM) for calibrated measurements and a TLM for raw measurements. Only the calibrated measurements TLM follows the reference frame shown in Figure 8.

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 19 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External
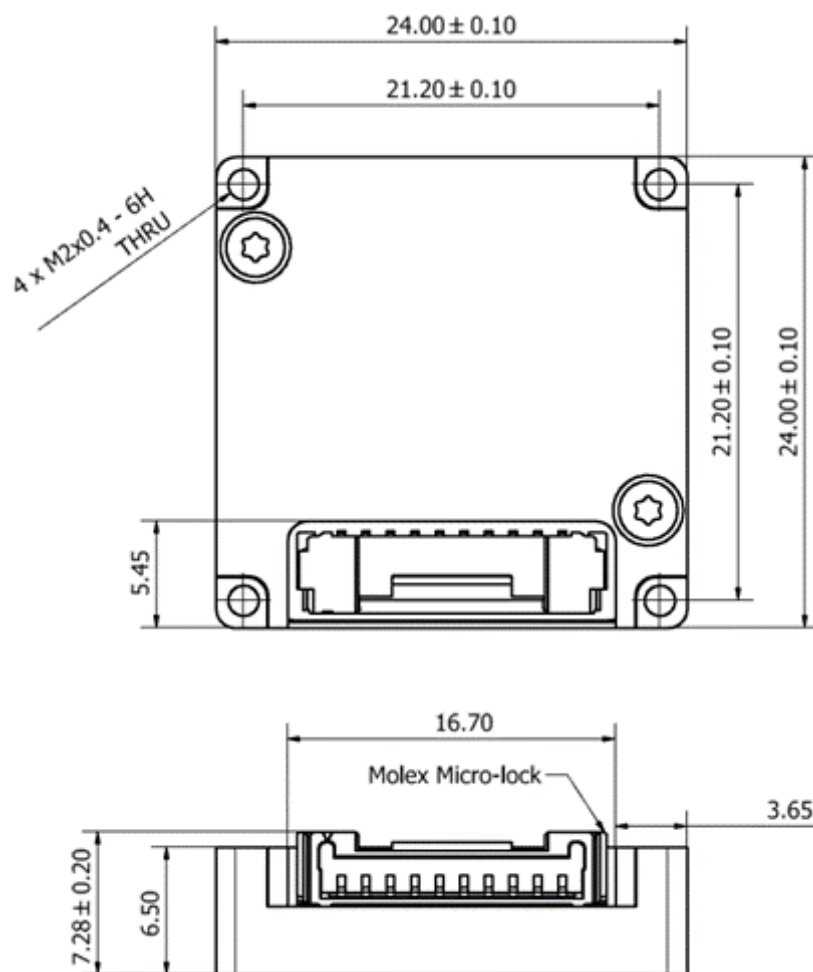
Figure 9: Indicative dimensions of CubeMag Compact

3.2.2 Mounting definition

The CubeMag Compact has four (4) M2x0.4mm threaded mounting holes that are used to secure the magnetometer. Non-ferrous screws should be used for securing this CubeProduct. This redundant magnetometer can be mounted with either the top or bottom face against the mounting surface. Regardless of the mounting orientation utilised, sufficient space should be allowed around the Molex connector to ensure easy and reliable connection.

The CubeMag Compact is designed to mount to an external surface of the satellite. The magnetometer should not be placed in close proximity of any other part of the satellite that causes significant disturbances. See [1] for more details.

3.2.3 Mass, COM and Inertia

The total mass of the CubeMag Compact is 8.0 g ± 5 %. The COM position of the CubeMag Compact is shown in Figure 10.

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 20 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

Figure 10: COM position of the CubeMag Compact

The moments of inertia of CubeMag Compact about the COM position are presented in Table 12, the axes reference for the inertias provided is shown in Figure 11.
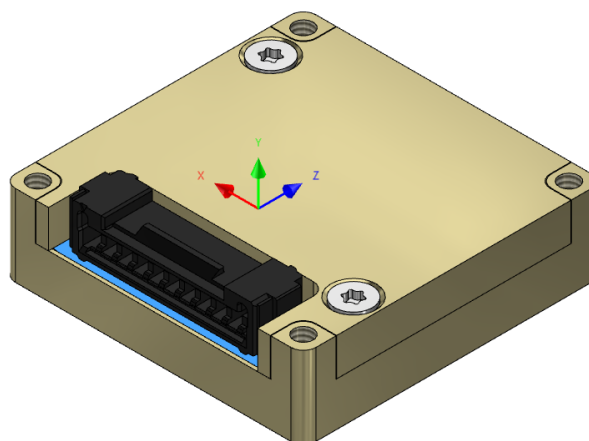
Figure 11: CubeMag Compact Inertial reference frame

Table 12: CubeMag Compact Moments of Inertia (MOI)

AXIS	VALUE
I_{xx} (gmm^2)	134 ± 10 %
I_{yy} (gmm^2)	212 ± 10 %
I_{zz} (gmm^2)	122 ± 10 %

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 21 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-O1

09/11/2023
1.02
External

3.2.4 Measurement Coordinate System Definition

The coordinate system of the CubeMag Compact is defined and shown in Figure 12. The CubeMag Compact has a TLM for calibrated measurements and a TLM for raw measurements. Only the calibrated measurements TLM follows the reference frame shown in Figure 12.
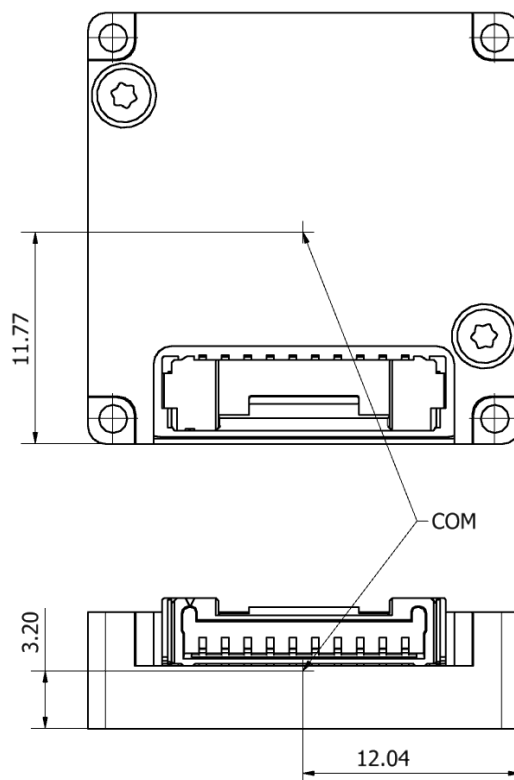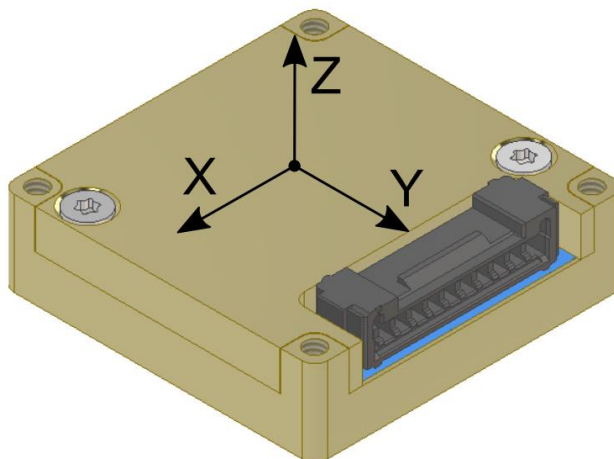

Figure 12: CubeMag Compact coordinate system definition

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 22 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

4 CubeMag Mass

Table 13 details the mass of the CubeMag.

Table 13: CubeMag mass

CUBEMAG	VARIANT/MODEL	MASS (G)[4]	NOTES
CubeMag	Deployable	14	Measured
	Compact	8	Measured

---

[4] 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).

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 23 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

5 EMI / EMC

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

5.1 Potential RF emitter list

Table 14: CubeMag Potential Emitters

CUBEMAG VARIANT	COMPONENT	EMITTER TYPE	FREQUENCY	FREQUENCY STABILITY
CubeMag Deployable	MCU	Crystal	24 MHz	± 50 ppm
	Comms UART	UART	0.92MHz	± 50 ppm
	Redundant Mag	I2C	100 kHz	± 50 ppm
	Magnetometer	SPI	370 kHz	± 50 ppm
	Temperature sensor	I2C	100 kHz	± 50 ppm
	Comms CAN	CAN	500 kHz	± 50 ppm
CubeMag Compact	Comms UART	UART	0.92MHz	± 50 ppm
	Comms CAN	I2C	500 kHz	± 50 ppm
	Red Mag	I2C	100 kHz	± 50 ppm
	MCU	Crystal	24 MHz	± 50 ppm

5.2 Minimising EMI / EMC effects

5.2.1 Grounding

The enclosure and mechanical parts of CubeMag are connected to the electrical ground through a filter designed to minimise EMI, as illustrated by Figure 13, with "ADCS node 1" representing the CubeMag. (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 CubeMag can be grounded by the user if desired.

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 24 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External
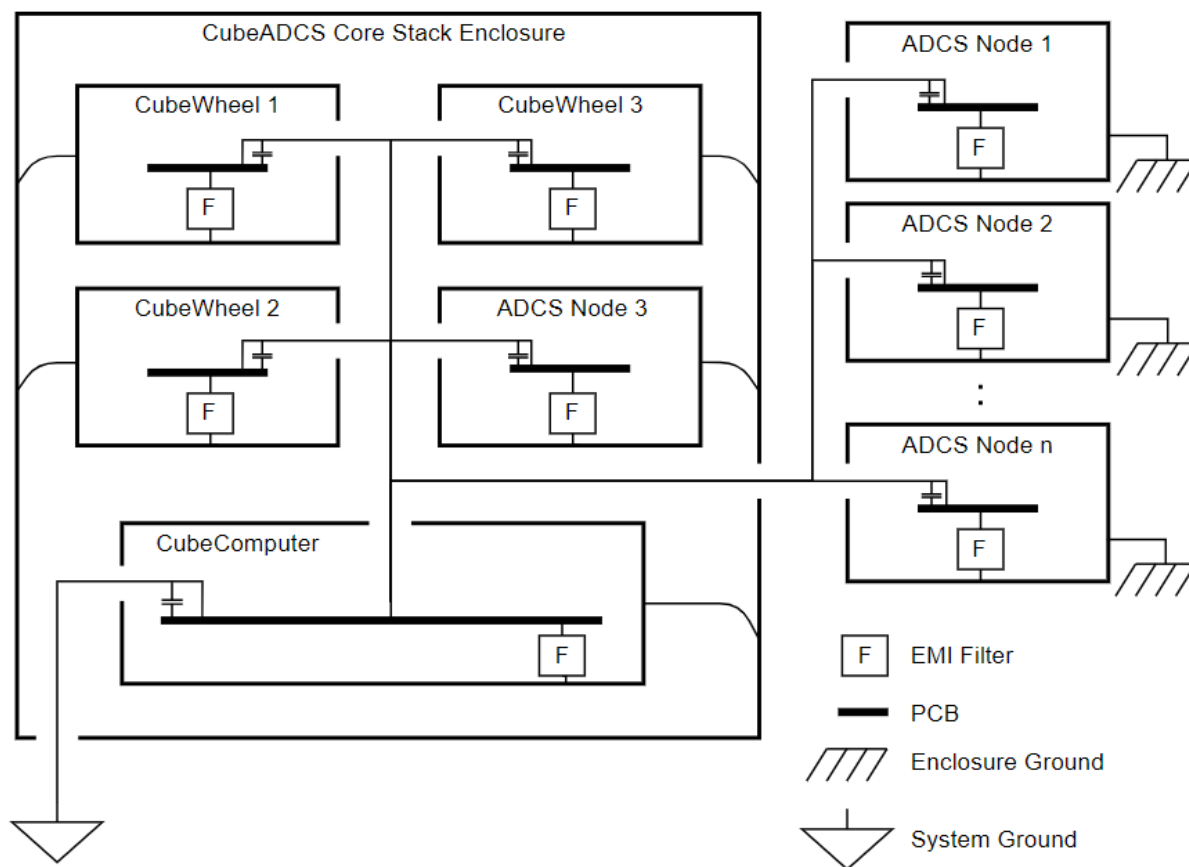
Figure 13: Generic Grounding diagram

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 CubeMag 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 CubeMag 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 CubeMag form twisted pairs as indicated in the tables below. CubeSpace will provide a 26AWG PTFE harness with each unit.

Table 15 shows the wire pairing depending on the communication protocol selected for the CubeMag deployable, note that only one communication protocol may be selected for the CubeMag deployable and this will affect the pairing of the wires. All communication lines are available on the CubeMag Compact with the twisted pairs are shown in Table 16.

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 25 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

Table 15: Twisted Wire Pairs on CubeMag Deployable Harness

PIN 1 NAME	PIN 2 NAME	COMMENT
3V3	GND	If CAN or RS485 is used
Enable	Boot	On CubeMag deployable Enable and Boot are paired
CANH	CANL	If CAN is used
RS485 A	RS485 B	If optional RS485 is used
3V3	UART_TX	If UART communication is used
GND	UART_RX	If UART communication is used

Table 16: Twisted Wire Pairs on CubeMag Compact Harness

PIN NAME 1	PIN NAME 2	COMMENT
Boot	UART_TX	
3V3	I2C_SDA	
CANH	CANL	
Enable	UART_RX	
GND	I2C_SCL	
RS485 A	RS485 B	If RS485 is used in place of UART
Boot	Enable	If RS485 is used in place of UART

Furthermore, the twisted wire pairs are braided/rolled to form the final harness. Figure 14 and Figure 15 below shows an example image of a final flight harness.

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 26 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

Figure 14: CubeMag Deployable Flight harness example

Figure 15: CubeMag Compact Flight harness example

5.2.4   Filtering and Suppression

The following noise filtering schemes are utilised on the CubeMag:

a.   All pins that are externally exposed through headers are filtered by way of 100pF decoupling to ground as shown in Figure 13.

b.   LC filtering is done on the CubeComputer's external 5V and 3.3V power supply input lines.
   - For the standalone CubeMag, 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 CubeMag, the client is requested to consider implementing similar on the client ADCS / OBC side – details can be provided.

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 27 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

d. Common-mode filtering is done on the CubeComputer's CAN communication interfaces (from the OBC, and to various CubeProducts).
    - For the standalone CubeMag, 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 CubeMag, the client is requested to consider implementing similar on the client ADCS / OBC side – details can be provided.

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 28 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

6 Environmental Qualification

CubeSpace has recently completed a so-called "re-spin" of all generation 2 CubeProducts, including the CubeMag. 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 CubeMag.

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 CubeMag, 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 CubeMag. The CubeMag 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 CubeMag, while not powered, is subjected to a hot start temperature of 70 degC. Once the soak period of minimum 30minutes have passed, the CubeMag is powered up and its start-up sequence is monitored for correct operation and if successful, a brief health check is done. The CubeMag is then powered down and temperature lowered to -35 degC and the power up sequence and brief heath check is repeated. The CubeMag is again powered down and brought back to ambient temperature. A complete ATP is then conducted and if all tests pass, the CubeMag 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 CubeMag is subjected to a full health check test procedure. Once all cycles have been completed, the CubeMag is subjected to a full Acceptance Test Procedure. If the CubeMag passes all tests, it is deemed to have passed TVAC testing at qualification levels.

Table 17: TVAC Hot cycle qualification levels

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

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 29 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

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 18: 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 CubeMag, 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 CubeMag is subjected to a full Acceptance Test Procedure. If the CubeMag passes all tests, it is deemed to have passed Vibration testing at qualification levels.

Table 19: 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 20: Qualification sine plus quasi-static levels

FREQUENCY (HZ)	AMPLITUDE (G) [0-PK]
5	1
10	2.5
21	2.5
25	15
30	15

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 30 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

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

Table 21: -3dB random vibration qualification levels

FREQUENCY (HZ)	AMPLITUDE (G²/HZ)
20	0.0282
50	0.0802
800	0.0802
2000	0.0130
Duration	60 seconds
Grms	10.02

Table 22: Random vibration qualification levels

FREQUENCY (HZ)	AMPLITUDE (G²/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 CubeMag, 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 CubeMag is subjected to a full Acceptance Test Procedure. If the CubeMag passes all tests, it is deemed to have passed Shock testing at qualification levels.

Table 23: 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

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 31 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

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.

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 32 of 33
Commercial in Confidence

CubeMag Generation 2
Interface Control Document (ICD)
CS-DEV.ICD.CM-01

09/11/2023
1.02
External

7 Materials used.

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

www.cubespace.co.za
info@cubespace.co.za

©2023 – CubeSpace Satellite Systems RF (Pty) Ltd
The LaunchLab, Hammanshand Rd, 7600, RSA

Page 33 of 33
Commercial in Confidence