CUBESPACE

Interface Control Document

CubeTorquer CR M2.1E1.0

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Revision History

Version	Authors	Date	Description
1.00	C. Leibbrandt	28/07/2023	First published version
1.01	C. Mailer	27/02/2025	Common ICD changes and improvements implemented.

Reference Documents

The following documents are referenced in this document.

[RD1]	CS-DEV.PD.CR-01	CubeTorquer Product Description Ver.1.00 or later
[RD2]	CS-DEV.UM.CR-01	CubeTorquer User Manual Ver.1.01 or later
[RD3]	CS-DEV.ETP.CA-01	Generic Environmental Test Plan Ver.1.05 or later

List of Acronyms/Abbreviations

ADCS	Attitude Determination and Control System
AWG	American Wire Gauge
CoM	Centre of Mass
EM	Engineering Model
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
FM	Flight Model
ICD	Interface Control Document
MoI	Moment of Inertia
MTQ	Magnetorquer
OBC	On-board Computer
PCB	Printed Circuit Board
PTFE	Polytetrafluoroethylene
PWM	Pulse Width Modulation

Table of Contents

1. Introduction 5
2. Electrical Interface 6
2.1 Power Interface 6
2.2 Electrical Model 6
2.2.1 Power and Signal Ground 7
2.3 Header Pinout and Electrical Characteristics 7
2.4 Harness Details 8
3. Mechanical Interface 9
3.1 Outer Dimensions 9
3.2 Mounting Definition 10
3.3 Mass, CoM and Inertia 11
3.4 Coordinate System Definition 11
4. EMI/EMC 12
4.1 EMI/EMC Cleanliness 12

Table of Tables

Table 1: Document Applicability 5
Table 2: Power Consumption 6
Table 3: Electrical Model Parameters 7
Table 4: Header Part Details 7
Table 5: Header Pinout and Electrical Characteristics 8
Table 6: Harness Details 8
Table 7: CubeTorquer Dimensions 10
Table 8: CubeTorquer Mass, CoM and Inertia Parameters 11

Table of Figures

Figure 1: CubeTorquer Simplified Electrical Model 6
Figure 2: CubeTorquer Header 7
Figure 3: Header Pin 1 Marker 8
Figure 4: Indicative Dimensions of CubeTorquer 9
Figure 5: CubeTorquer Relative Placement 10
Figure 6: CubeTorquer CoM Position 11
Figure 7: CubeTorquer Coordinate System and Magnetic Polarity Definition 11

1. Introduction

The purpose of this document is to provide information on how to correctly interface with the CubeTorquer. This includes 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 CubeTorquer if the specifications provided in this document are not adhered to.

This ICD applies to the CubeTorquer hardware versions described in Table 1.

Table 1: Document Applicability

Variant	Version	Notes
CR0002	M2.0E1.0, M2.1E1.0	M2.0E1.0: Alodine conversion coating (gold colour) M2.1E1.0: SurTec 650 conversion coating (silver colour)
CR0003, CR0004		
CR0006		
CR0008, CR0010		
CR0012		
CR0020		

2. Electrical Interface

2.1 Power Interface

CubeTorquers are primarily used for stabilising a satellite during detumbling, and for desaturating the reaction wheels of their stored angular momentum during regular satellite operations. During detumbling the CubeTorquers are often driven at maximum duty cycle of 80%, whereas for desaturating reaction wheels during regular operations the duty cycle is typically less than 10%. Table 2 gives the peak current and power consumption of CubeTorquer variants at these typical duty cycles.

Table 2: Power Consumption

Variant	Linear Voltage	Linear Current[1]	Average Power for 10% on-time[2]	Average Power for 80% on-time[3]
CR0002	5 V	98 mA	123 mW	981 mW
CR0003		74 mA		
CR0004		125 mA	188 mW	1500 mW
CR0006		111 mA	167 mW	1334 mW
CR0008		113 mA	168 mW	1349 mW
CR0010		134 mA	200 mW	1600 mW
CR0012		137 mA	206 mW	1644 mW
CR0020		154 mA	231 mW	1847 mW

2.2 Electrical Model

CubeTorquer can be modelled as a resistor and inductor connected in series. The full theoretical model includes both an electric and magnetic resistance and inductance, but for the sizes in the CubeTorquer range, the simplified model is sufficiently accurate. The simplified model is illustrated in Figure 1.

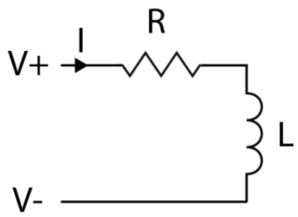

Figure 1: CubeTorquer Simplified Electrical Model

The Resistance (R) and Inductance (L) values for the various CubeTorquer variants are provided in Table 3. As expected for an R-L series combination, a CubeTorquer has a time constant $\tau = L/R$, as shown.

[1] Measured at 20-25°C ambient temperature. Resistance, and therefore current, will vary with temperature.

[2] Measured with a 1 Hz duty cycle at linear voltage, excluding local DC-DC regulation losses.

[3] CubeTorquer actuation is limited to 80% of the ADCS control loop to allow undisturbed sampling of the magnetometer.

Table 3: Electrical Model Parameters

Variant	Linear Magnetic Dipole Moment @ 5V	Resistance[4]	Inductance[5]	Time Constant
CR0002	0.2 Am^2	51.0 Ω	0.26 H	5.0 ms
CR0003	0.3 Am^2	66.5 Ω	0.45 H	6.7 ms
CR0004	0.4 Am^2	39.5 Ω	0.26 H	6.5 ms
CR0006	0.6 Am^2	45.0 Ω	0.34 H	7.6 ms
CR0008	0.8 Am^2	44.5 Ω	0.32 H	7.2 ms
CR0010	1.0 Am^2	37.5 Ω	0.38 H	10.1 ms
CR0012	1.2 Am^2	36.5 Ω	0.31 H	8.4 ms
CR0020	2.0 Am^2	32.5 Ω	0.37 H	11.4 ms

2.2.1 Power and Signal Ground

CubeTorquer does not have separate power and signal ground. The windings are isolated from the chassis.

2.3 Header Pinout and Electrical Characteristics

All CubeTorquer variants share a common header connector, shown in Figure 2 as part of a CubeTorquer variant CR0003, with details in Table 4.

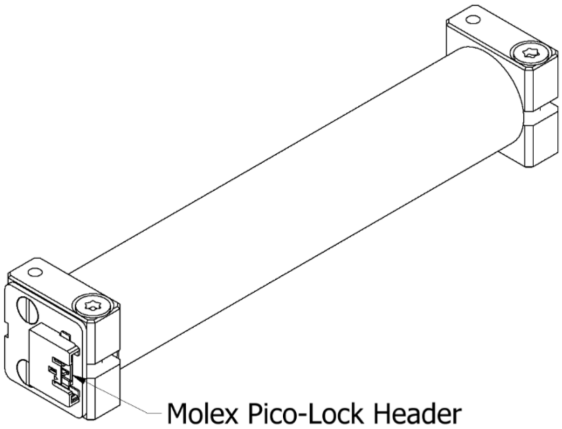

Figure 2: CubeTorquer Header

Table 4: Header Part Details

Part	Description	Part Number
Header	Molex Pico-Lock, Single Row	5037630291
Mating Housing	Molex Pico-Lock, Single Row, Receptable Crimp Housing	5037640201
Housing Terminal	Molex Pico-Lock, Female Crimp Terminal	5037650098

[4] Manufacture resistance at 20-25°C ambient temperature with a tolerance of ±1.0 Ω.

[5] Inductance values are calculated from the measured resistance and time constant.

Table 5: Header Pinout and Electrical Characteristics

Pin #	Pin Name	Pin Description	IO Type	Voltage Range
1	T+	CubeTorquer Pin 1 (V+)	Input, PWM	0 – 5V
2	T-	CubeTorquer Pin 2 (V-)	Input, PWM	0 – 5V

Pin 1 on the header is designated with a triangular symbol, as illustrated in Figure 3.

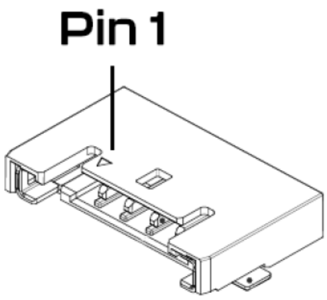

Figure 3: Header Pin 1 Marker

2.4 Harness Details

A standalone CubeTorquer 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 6. The standard lengths 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 6: Harness Details

Harness	Std. Length [mm][6]	No. Wires	Wire Gauge [AWG]	Wire Mass [g/m]	Housing Mass [mg]	Terminal Mass [mg]
FM Pigtail	400, 800, 1200	2	28	1.4	138	35.5

[6] Standard harness length will depend on the torquer variant and should be confirmed at order placement.

3. Mechanical Interface

CubeTorquer consists of two aluminium (6082-T6) mounting brackets, surface treated with a conversion coating, on either end of an alloy core and wound coil.

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.

In addition to the mounting holes, each mounting bracket also has a screw for permanently securing it onto the wound core. Do not loosen or remove this screw.

3.1 Outer Dimensions

The physical size and mounting points for the CubeTorquer variants are given in Table 7. The dimensions provided in Table 7 refer to symbols in Figure 4.

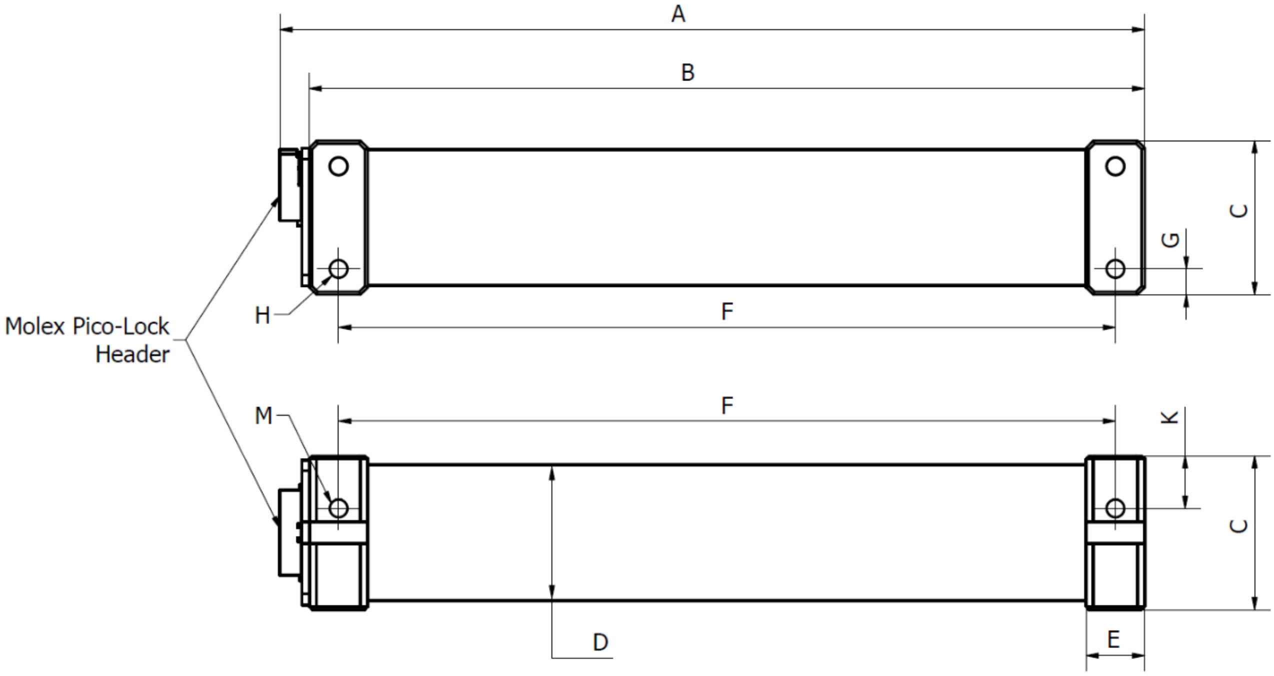

Figure 4: Indicative Dimensions of CubeTorquer

Table 7: CubeTorquer Dimensions

<table>
<tr><th>Variant</th><th>A [mm]</th><th>B [mm]</th><th>C [mm]</th><th>D [mm]</th><th>E [mm]</th><th>F [mm]</th><th>G [mm]</th><th>H [mm]</th><th>K [mm]</th><th>M [mm]</th></tr>
<tr><td>CR0002</td><td>47.0</td><td>45.0±0.2</td><td rowspan="6">10.5±0.1</td><td>9.3</td><td rowspan="6">4.0</td><td>41.0±0.1</td><td rowspan="8">1.75±0.05</td><td rowspan="8">M1.6X0.35 THRU</td><td rowspan="6">3.60±0.05</td><td rowspan="8">M1.6X0.35 3.2 DEEP</td></tr>
<tr><td>CR0003</td><td>59.0</td><td>57.0±0.2</td><td>9.3</td><td>53.0±0.1</td></tr>
<tr><td>CR0004</td><td>59.0</td><td>57.0±0.2</td><td>9.0</td><td>53.0±0.1</td></tr>
<tr><td>CR0006</td><td>77.0</td><td>75.0±0.2</td><td>9.1</td><td>71.0±0.1</td></tr>
<tr><td>CR0008</td><td>92.0</td><td>90±0.2</td><td>8.4</td><td>86.0±0.15</td></tr>
<tr><td>CR0010</td><td>92.0</td><td>90±0.2</td><td>8.4</td><td>86.0±0.15</td></tr>
<tr><td>CR0012</td><td>122.0</td><td>120.0±0.3</td><td rowspan="2">13.0±0.1</td><td>8.3</td><td rowspan="2">5.0</td><td>115.0±0.2</td><td rowspan="2">4.8±0.05</td></tr>
<tr><td>CR0020</td><td>152.0</td><td>150.0±0.3</td><td>8.0</td><td>145.0±0.2</td></tr>
</table>

3.2 Mounting Definition

A CubeTorquer can be mounted on one of three faces, using a pair of mounting holes. The two mounting faces that are parallel to one another share a threaded hole that passes through the full length of the bracket. The third mounting face has a dedicated threaded hole. For hole specifications, refer to Figure 4 and Table 7.

A CubeTorquer should always be mounted to a rigid and flat surface, far from any magnetometers or other components which are sensitive to the magnetic field produced by a CubeTorquer.

Placement and arrangement of CubeTorquers within the satellite should be carefully considered to ensure that neighbouring rods do not crosstalk. Figure 5 indicates some valid and invalid placement options of two CubeTorquers with respect to one another. Each combination of two CubeTorquers within the set of three must adhere to these placement rules.

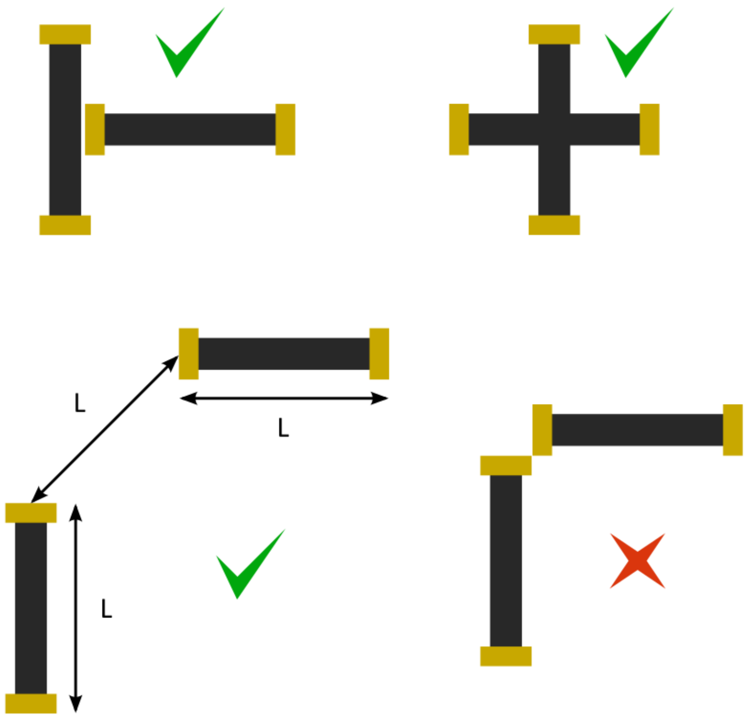

Figure 5: CubeTorquer Relative Placement

3.3 Mass, CoM and Inertia

The position of the centre of mass (CoM) is shown in Figure 6, with the labelled dimensions given in Table 8. The moments of inertia (MoI) of CubeTorquer about its CoM are also presented in Table 8.

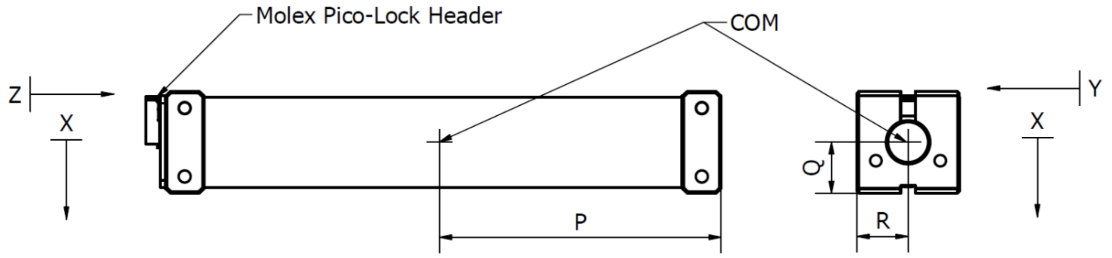

Figure 6: CubeTorquer CoM Position

Table 8: CubeTorquer Mass, CoM and Inertia Parameters[7]

Variant	Mass [g][8]	P [mm]	Q [mm]	R [mm]	I_{XX} [gmm²]	I_{YY} [gmm²]	I_{ZZ} [gmm²]
CR0002	16	22.96	5.31	5.26	2889	2886	170
CR0003	24	28.89	5.29	5.26	6659	6656	246
CR0004	23	28.92	5.29	5.26	6241	6239	215
CR0006	31	37.89	5.28	5.25	14933	14930	301
CR0008	30	45.49	5.28	5.52	21556	21553	242
CR0010	37	45.39	5.28	5.52	25564	25561	321
CR0012	45	60.43	6.53	6.52	60299	60293	415
CR0020	54	75.45	6.53	6.52	111583	111577	462

3.4 Coordinate System Definition

The CubeTorquer coordinate system definition is shown in Figure 7. This figure also shows the magnetic moment direction generated when a positive voltage on Pin V+ relative to Pin V- is applied.

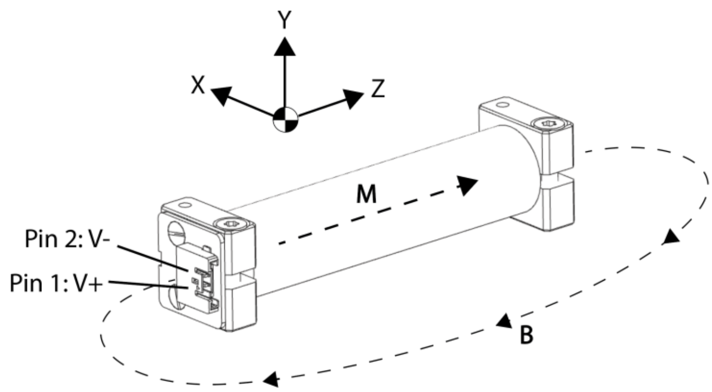

Figure 7: CubeTorquer Coordinate System and Magnetic Polarity Definition

[7] CoM and MoI are CAD computed properties.

[8] Mass of CubeTorquer only, excluding harness.

4. EMI/EMC

4.1 EMI/EMC Cleanliness

When actuated, a CubeTorquer generates a strong magnetic field which may interfere with magnetically sensitive components, such as magnetometers, and can magnetise nearby ferromagnetic materials. This electromagnetic interference (EMI) is most pronounced during active pulses and is established or decays at a rate determined by the inductance and time constant of the CubeTorquer.

In the CubeSpace ADCS, CubeTorquers are driven by a 1 Hz PWM with maximum duty-cycle of 80%. Magnetometer sampling occurs between pulses, after the magnetic field has decayed, to minimize interference. Similarly, to reduce EMI effects, avoid simultaneous operation of CubeTorquer with magnetically sensitive components and position the CubeTorquer as far as practical from these elements.