CUBESPACE

# Interface Control Document

## CubeWheel: NanoSat Range

| | |
|---|---|
| DOCUMENT NUMBER | CS-DEV.ICD.CW-01 |
| VERSION | 1.06 |
| DATE | 16/04/2026 |
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# Revision History

| VERSION | AUTHORS | DATE | DESCRIPTION |
|---|---|---|---|
| 1.00 | C. Leibbrandt | 14/06/2023 | Published |
| 1.01 | J. Miller | 14/07/2023 | Update to Table 19 |
| 1.02 | J. Miller | 10/10/2023 | Update torque graphs and tables. |
| 1.03 | J. Miller | 13/02/2025 | Moved data to Technical Reference Manual [RD3]. Common ICD changes implemented. Updates to reflect CubeWheel grouping into NanoSat and SmallSat ranges, this document becomes more specifically for the CW NanoSat range. |
| 1.04 | J. Miller | 04/03/2025 | Updated CW0500 Power Parameters. |
| 1.05 | J. Miller | 04/08/2025 | Added isolated pyramid mounting specifications. Increased minimum supply voltage for CW0500. Standardised on non/isolate pyramid product variant codes. |
| 1.06 | C. Mailer | 16/04/2026 | Corrected CW0162P mounting hole A4 Y dimension in Table 19 to match CAD and physical unit. |

# Reference Documents

The following documents are referenced in this document.

[RD1] CS-DEV.PD.CW-01 CubeWheel Product Description Ver.1.00 or later
[RD2] CS-DEV.UM.CW-01 CubeWheel User Manual Ver.1.00 or later
[RD3] CS-DEV.REF.CW-01 CubeWheel CubeSat Technical Reference Manual Ver.1.00 or later
[RD4] CS-DEV.ETP.CA-01 General Environmental Test Plan Ver.1.05 or later
[RD5] 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 |
| EMC | Electromagnetic Compatibility |
| EMI | Electromagnetic Interference |
| FM | Flight Model |
| I2C | Inter-Integrated Circuit |
| MCU | Microcontroller Unit |
| OBC | On-board Computer |
| PCB | Printed Circuit Board |
| PTFE | Polytetrafluoroethylene |
| RF | Radio Frequency |
| RWL | Reaction Wheel |
| 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 CubeWheel. 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 CubeWheel if the specifications provided in this document are not adhered to.**

The CubeWheel sizes have been grouped into two ranges based on their momentum storage capability, namely the Nanosat range and SmallSat range. This ICD applies to the products and hardware versions of the NanoSat range, listed in Table 1.

**Table 1: Document Applicability**

| CubeProduct | Wheel Size | Version | Notes |
|---|---|---|---|
| CubeWheel | CW0017<br>CW0057<br>CW0162 | M2.0E2.3 | - |
| | CW0500 | M2.1E1.3 | - |
| CubeWheel Pyramid (Non-isolated) | PYR400-0017<br>PYR400-0057<br>PYR400-0162<br>PYR400-0500 | | |
| CubeWheel Pyramid (Isolated) | PYR410-0500 | M1.1 | |

# 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/RS485 Characteristics*

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

**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.

### *2.1.3 I2C Characteristics*

I2C communication is not available on all CubeWheels. Where it is available, CubeWheel is always configured as slave on the I2C bus and cannot initiate communications by itself. It is important to note that the master that communicates with the CubeWheel must support clock stretching.

**Table 4: I2C Characteristics**

| Parameter | Value |
|---|---|
| Supported CubeWheels | CW0017, CW0057, CW0162 |
| 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 |
| Default 7-bit Address | 0x68 |

### *2.1.4 Boot Line*

CubeWheel 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

The typical power characteristics are independent of the satellite's size or control mode being used.

**Table 5: External Power Supply Requirements**

| External power | CW0017 | CW0057 | CW0162 | CW0500 |
|---|---|---|---|---|
| Digital Supply Voltage [V] | 3.3 | 3.3 | 3.3 | 3.3 |
| Motor Supply Voltage Range ($V_{bat}$) [V] | 6.4-16.8 | 6.4-16.8 | 6.4-16.8 | 12-24 |
| Nominal Motor Supply Voltage [V] | 8 | 12 | 12 | 12 |
| Minimum Supply Current [A] | 0.5 | 1 | 1 | 2.0 |

**Table 6: Power Consumption on 3.3 V Line**

| Parameter | Value | Notes |
|---|---|---|
| Average current | 32 mA | Measured for all wheel variants. |
| Average power | 106 mW | |
| Max current | 79 mA | |
| Max power | 261 mW | |
| Inrush current | 270 mA | |
| Inrush current duration | 5 µs | |

### 2.2.1 Enable Line

CubeWheel 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

CubeWheel implements an input power switch on the 3.3 V line 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

It is recommended that the client ADCS/OBC implements voltage monitoring on the 3.3 V line to CubeWheel to ensure that it is always within the range specified in Table 5: External Power Supply Requirements. It is also recommended that the client ADCS/OBC implements current limiting on the 3.3 V line to CubeWheel to mitigate the effects of a latch-up in the case of a fault.

### 2.2.4 Power and Signal Ground

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

## 2.3 CubeWheel Power Characteristics

To achieve the maximum rotation speed and thus momentum storage, the wheels require a minimum battery supply voltage, as defined in Table 5. Lower battery supply voltages will result in a correspondingly lower momentum storage capacity. Similarly, a minimum current is required to achieve the maximum torque; less powerful supplies will achieve a correspondingly lower maximum torque from the wheels.

### 2.3.1 Power Consumption on the Battery Voltage Rail

The CubeWheels (as reaction wheels) facilitate rotating a spacecraft to a required attitude, and for maintaining a desired attitude by counteracting in-orbit disturbance torques. The power consumption of reaction wheels depends on the running speed and the torque demand. The maximum current and power characteristics are provided in Table 7, but more current draws at different momentum levels and torques are provided in [RD3].

**Table 7: Power Consumption on Battery Voltage Rail**

| CubeWheel Variant | Power at rated momentum [W] | Max current[1] at 12V [mA] | Peak power[2] [W] |
|---|---|---|---|
| CW0017 | 0.3 | 370 | 0.85 |
| CW0057 | 0.77 | 656 | 2.7 |
| CW0162 | 0.77 | 952 | 7.2 |
| CW0500 | 3.4 | 1250 | 15 |

The CubeWheel design has been optimized to minimize inrush current demand on the battery supply, characteristics of which are given in Table 8. Two primary instances of inrush current are identified: the first occurs when the battery supply to the wheels is enabled by the power distribution system, and the second occurs upon activation of the motor power. It is important to note that activation of motor power is an internal function, triggered either automatically or via telecommand.

**Table 8: Battery Inrush Current Characteristics**

| Model | Nominal Supply voltage [V] | Inrush Current [mA] | Duration [mS] | Instance |
|---|---|---|---|---|
| CW0017 | 8.0 | 110 | 0.04 | Power Supply Enable |
| CW0057 | 12.0 | 110 | 0.08 | Power Supply Enable |
| CW0162 | 12.0 | 110 | 0.08 | Power Supply Enable |
| CW0500 | 12.0 | 2280/720 | 0.140/12 | Power Supply Enable/Motor Power Enable |

### *2.3.2 Battery Voltage Power Switch*

There is overvoltage protection on the $V_{bat}$ bus line. If $V_{bat}$ falls outside the range specified in Table 5: External Power Supply Requirements, power to the motor driver will be automatically switched off.

**Table 9: Battery Voltage Input Power Switches**

| CubeWheel Variant | $V_{bat}$ Input Protection Cutoff | $V_{bat}$ Circuit Damage Limit |
|---|---|---|
| CW0017, CW0057, CW0162 | See Table 5. | 20 V |
| CW0500 | See Table 5. | 40 V |

[1] The maximum current is drawn in short pulses at 24 kHz, the frequency of the motor driver PWM.

[2] The peak power is defined as the maximum power drawn when the wheel accelerates through rated momentum speed at the nominal torque, including both battery and digital power components.

## 2.4 Header Pinout and Electrical Characteristics

**Table 10: Header Part details**

| Part | Description | Part Number |
|---|---|---|
| Header | Molex Micro-Lock Plus PCB Header | 5055671481 |
| Mating housing | Molex Micro-Lock Plus Receptacle Crimp Housing | 5055651401 |
| Housing terminal | Molex Micro-Lock Female Crimp Terminal | 5054311100 |

**Table 11: 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[3] /GND | I2C bus data Line/<br>Power and signal ground* | Input | 2.7 to 5.5V |
| 3. | 3V3 | Digital 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_H | High level CAN bus line | LVDS | 0 to 3.4 |
| 6. | CAN_L | Low level CAN bus line | LVDS | 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[3] /GND | I2C bus clock line | Input | 2.7 to 5.5V |
| 10. | Enable | Toggle power on<br>Active-high | Input | -0.5 to 3.4 |
| 11. | GND | Power and signal ground | Power | 0 |
| 12. | GND | Power and signal ground | Power | 0 |
| 13. | VBAT | Supply voltage for motor driver | Power | Refer to Table 5 [4] |
| 14. | VBAT | Supply voltage for motor driver | Power | Refer to Table 5 [4] |

## 2.5 Harness Details

A standalone CubeWheel 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

[3] For the CW0500 where I2C is not available, Pin 2 and Pin 9 are connected to GND.

[4] The voltage applied to the motor determines the maximum steady state speed.

described in Table 12. 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 12: Harness Details**

| Harness | No. Wires | Wire Gauge (AWG) | Wire mass (kg/km) | Housing mass (mg) | Terminal mass (mg) | Total Mass |
|---|---|---|---|---|---|---|
| FM pigtail | 14 | 26 | 1.96 | 263.5 | 35.434 | Length Dependant |

## 2.6 CubeWheel Pyramid Electrical Interface

The CubeWheel pyramid has four separate electrical interfaces, one for each reaction wheel, each the same as defined in section 2.

# 3. Mechanical Interface

CubeWheels are offered as single wheels (usually 3 wheels as an XYZ configuration), and in a 4-wheel pyramid configuration which offers increased performance and redundancy. This section of the ICD presents standalone wheels first, and then wheels as a pyramid assembly.

## 3.1 Standalone CubeWheels

The CubeWheel reaction wheel comprises a high-performance electric motor driving a balanced flywheel. These components are housed within a robust enclosure made from 6082-T6 aluminium treated with a chromate conversion coating.

### *3.1.1 Outer Dimensions*

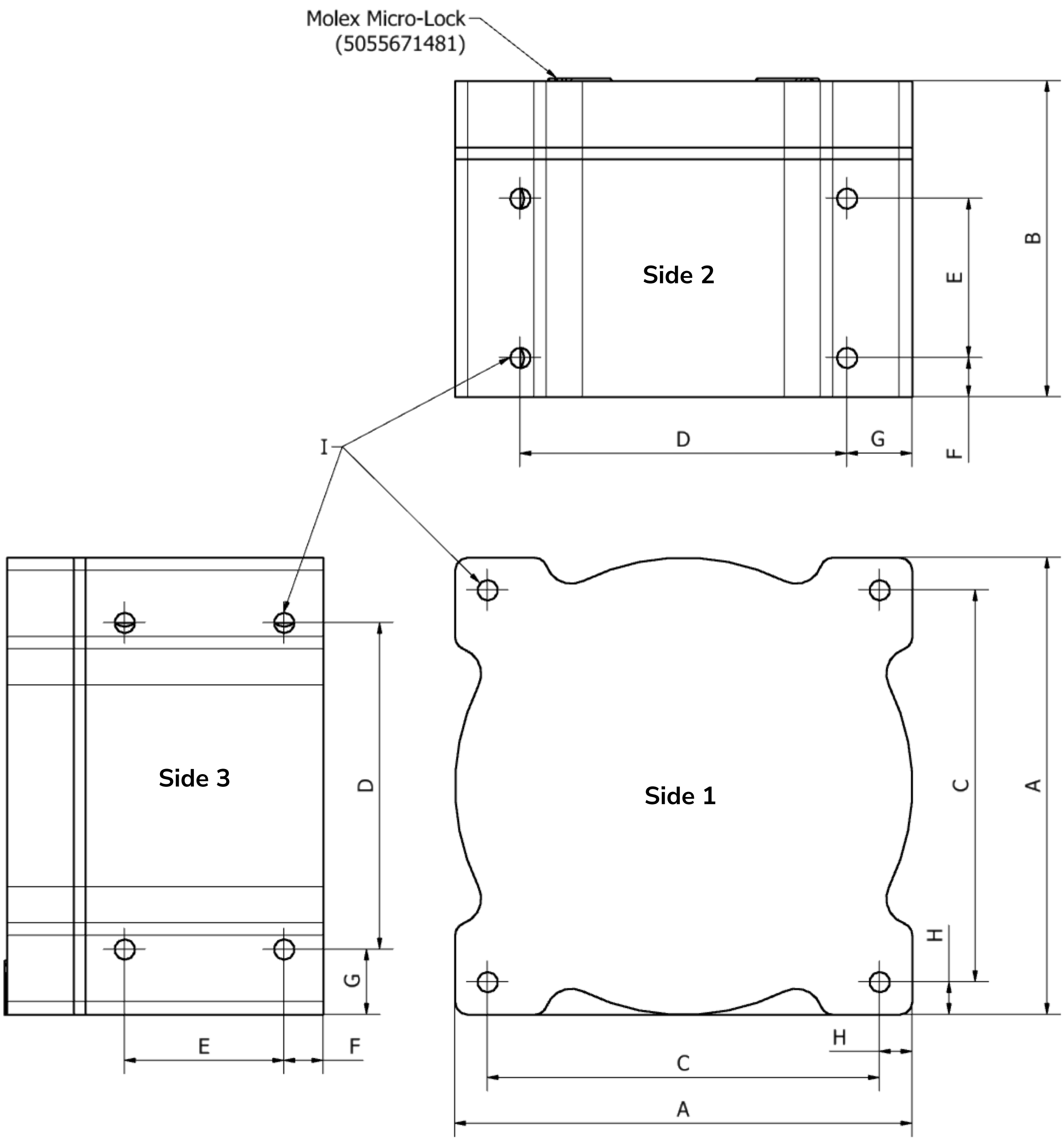


**Figure 1: Indicative Dimensions of CubeWheel**

**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.**

**Table 13: CubeWheel Dimensions**

| Model | A (mm) | B (mm) | C (mm) | D (mm) | E (mm) | F (mm) | G (mm) | H (mm) | I |
|---|---|---|---|---|---|---|---|---|---|
| CW0017 | 28.0±0.1 | 26.0±0.1 | 23.0±0.1 | 23.0±0.1 | 10±0.1 | 5.0 | 2.5 | 2.5 | M2x0.4 4.0 Deep |
| CW0057 | 35.0±0.1 | 24.2±0.2 | 30.0±0.1 | 25.0±0.1 | 12.2±0.1 | 3.0 | 5.0 | 2.5 | M2x0.4 4.0 Deep |
| CW0162 | 46.2±0.1 | 24.2±0.2 | 39.8±0.1 | 32.2±0.1 | 13.2±0.1 | 2.5 | 7.0 | 3.2 | M3x0.5 4.5 Deep |
| CW0500 | 66.0±0.1 | 26.0±0.2 | 56.8±0.1 | 45.5±0.1 | 11.5±0.1 | 2.75 | 10.25 | 4.6 | M4x0.7 6.0 Deep |

### *3.1.2 Mounting Definition*

Each CubeWheel has three orthogonal faces with four mounting holes on each face, see Figure 1. Mounting of wheels should be to a rigid part of the satellite and ideally to more than one side of the wheel. Improper mounting or a flimsy mounting structure can easily result in vibration amplification that could damage the wheel bearings. The temperature of the mounting interface to which the CubeWheel is fastened should not exceed the limits as defined in Table 15. Fasten the wheels using a torque wrench according to Table 14 below. Ensure that all mounting screws are staked using non-outgassing adhesive before conducting vibration tests.

**Table 14: Recommended Wheel Mounting Screw Torques**

| Product | Mounting Hole | Recommended Torque [cN.m] |
|---|---|---|
| CW0017, CW0057 | M2 threaded aluminium. | 26 |
| CW0162 | M3 threaded aluminium. | 87 |
| CW0500 | M4 threaded aluminium. | 207 |

**Table 15: Mounting Interface Temperature Range**

| Product | Minimum Temperature [°C] | Maximum Temperature [°C] |
|---|---|---|
| All Units | -15.0 | 50.0 |

### 3.1.2.1 Mounting Relief Cut-out (CW0500 Only)

**For certain CW0500 mounting configurations, a relief cut-out in the mounting surface is required to ensure proper behaviour of the internal damping.**

A relief cut in the mounting surface is needed for mounting CW0500 on side 2 or side 3, as in Figure 1. The relief cut details are shown in Figure 2, and dimensions in given Table 16.

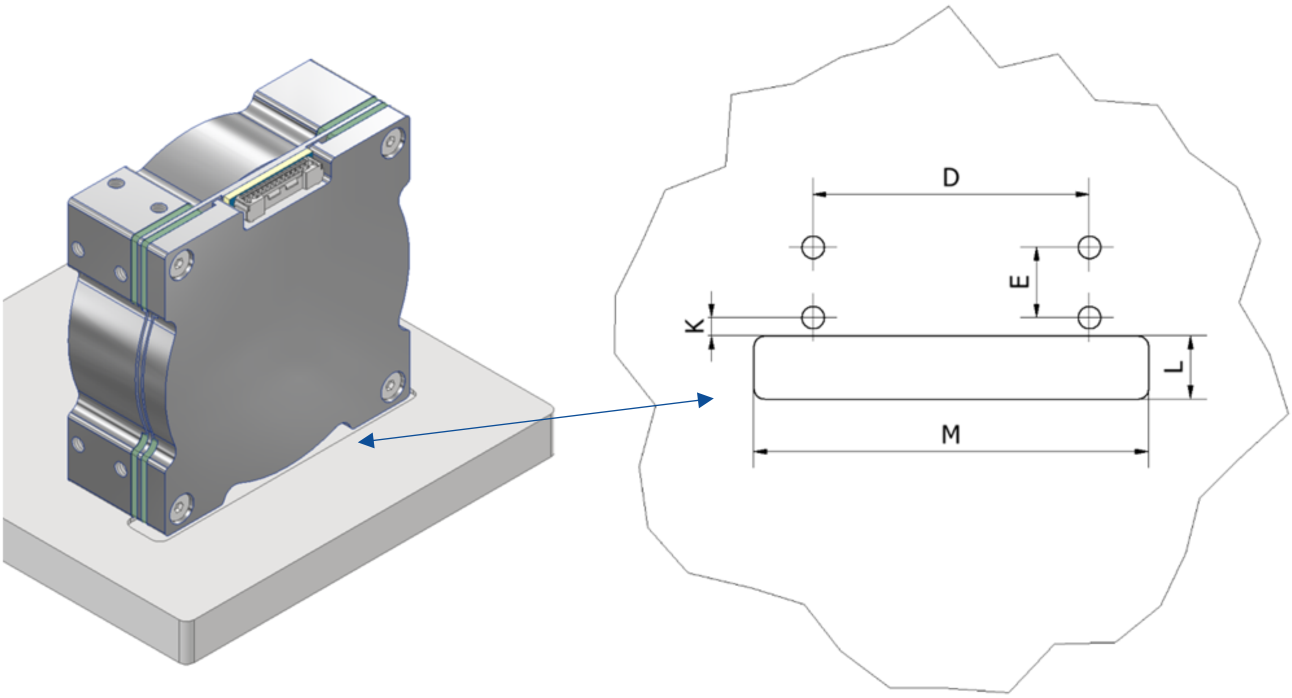


**Figure 2: CW0500 Mounting Surface Relief Cut**

**Table 16: CW0500 Mounting Surface Relief Cut Dimensions**

| CubeWheel Variant | K (mm) | L (mm) | M (mm) | Relief Depth (mm) | Corner Radius (mm) |
|---|---|---|---|---|---|
| CW0500 | 2.50 | 10.0 | 70.0 | 1.0 | 2.0 |

### *3.1.3 Mass, CoM and Inertia*

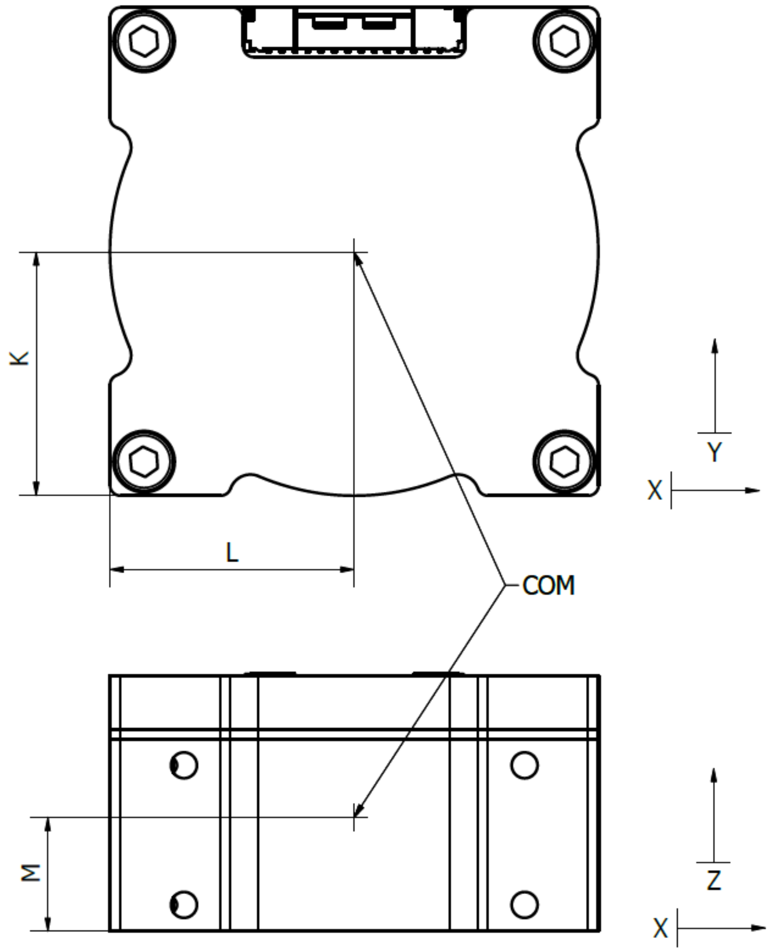


**Figure 3: CoM Position of CubeWheel**

Specific dimensions for interpreting Figure 3 are given in Table 17, along with flywheel inertia. The flywheel is free to spin when the motor is not actively controlling the rotation and should therefore not contribute to the total satellite inertia. The axes definition for interpreting MoI is provided in Figure 4.

**Table 17: Mass, CoM and Inertia Details**

| Model | Mass (g) | CoM (mm) | | | Inertia around CoM (gmm²) | | | Flywheel inertia (gmm²) |
|---|---|---|---|---|---|---|---|---|
| | | K | L | M | $I_{xx}$ | $I_{yy}$ | $I_{zz}$ | |
| CW0017 | 52 | 14.12 | 13.62 | 12.24 | 5398 ± 10% | 5618 ± 10% | 6317 ± 10% | 2128 |
| CW0057 | 105 | 17.36 | 17.51 | 9.89 | 12894 ± 10% | 12774 ± 10% | 18389 ± 10% | 9510 |
| CW0162 | 144 | 23.04 | 23.08 | 10.78 | 32021 ± 10% | 31873 ± 10% | 52100 ± 10% | 25997 |
| CW0500 | 322 | 33.12 | 33.08 | 11.98 | 125824 ± 10% | 125367 ± 10% | 220680 ± 10% | 83563 |

### 3.1.4 Coordinate System Definition

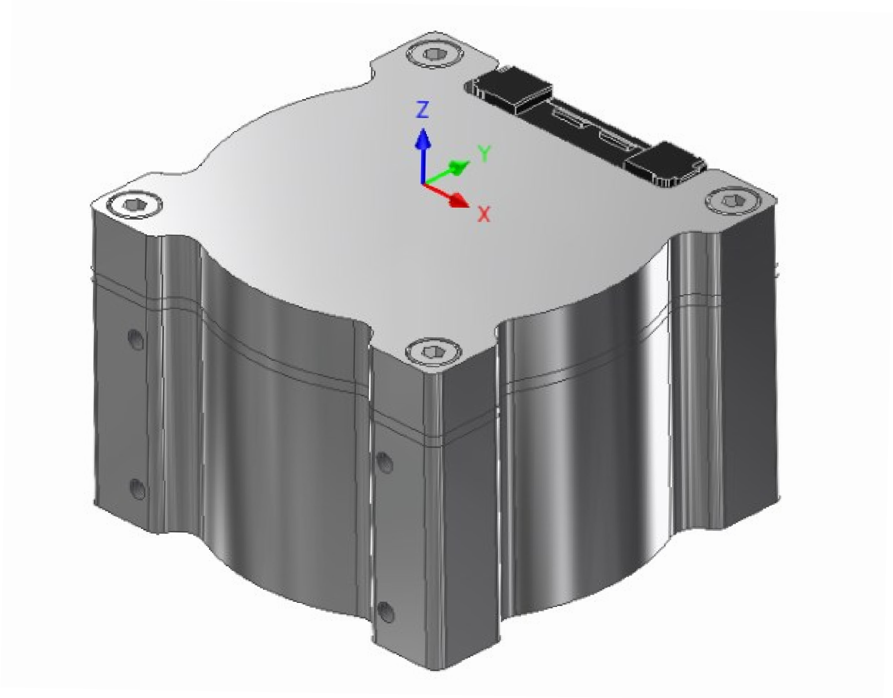


**Figure 4: CubeWheel Coordinate System Definition**

A positive rotation, resulting from a positive wheel speed reference command or torque command, can be translated to an angular momentum vector pointing out of the top of CubeWheel as shown in Figure 5.


**Figure 5: CubeWheel Momentum Definition**

## 3.2 CubeWheel Pyramid

The CubeWheel pyramid consists of four CubeWheels mounted in a pyramid configuration. Each reaction wheel in the pyramid configuration is inclined at a specific angle enabling them to contribute to more than one axis of control. This arrangement has several advantages over three orthogonal wheels, including redundancy and reduced zero-crossings, increasing reliability and control accuracy.

Two variations of the CubeWheel pyramid exist: a non-isolated (PYR400) and an isolated (PYR410) solution. The isolated pyramid will reduce any transfer of micro-vibrations from the reaction wheels onto the satellite body. An example of each pyramid assembly is presented in

Figure 6.

Isolated solutions for the CW0017P and CW0057P, CW0162P are not active on the development plan. However, these may be designed upon request.

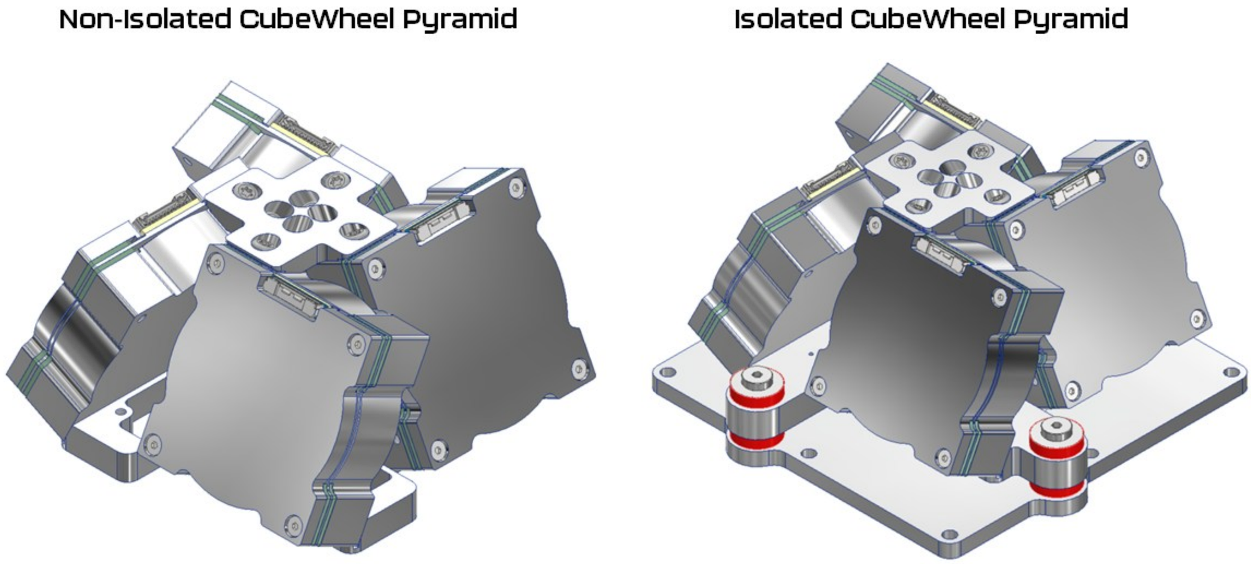


**Figure 6: Example of Non-Isolated (left) and Isolated (right) CubeWheel Pyramid Configurations**

## 3.2.1 CubeWheel Pyramid (Non-isolated)

### 3.2.1.1 Outer Dimensions

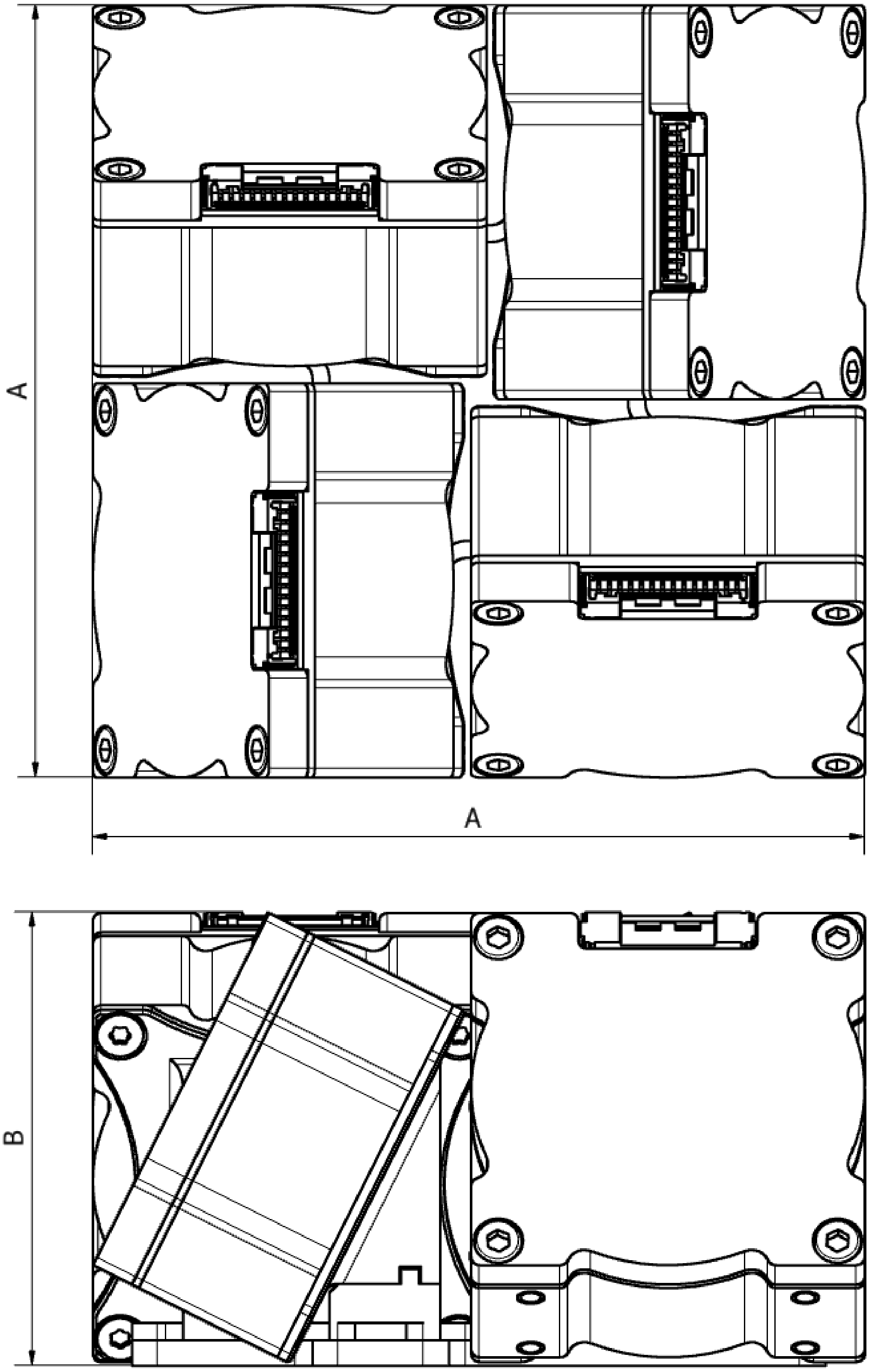


**Figure 7: Indicative Dimensions of a CubeWheel Pyramid Assembly**

The dimensions shown in Figure 7 for each CubeWheel pyramid configuration are provided in Table 18.

**Table 18: CubeWheel Pyramid Dimensions**

| Pyramid Model | Reaction Wheels | A (mm) | B (mm) |
|---|---|---|---|
| PYR400-0017 | 4x CW0017 | 67.00±0.5 | 41.84±0.3 |
| PYR400-0057 | 4x CW0057 | 73.90±0.5 | 43.27±0.3 |
| PYR400-0162 | 4x CW0162 | 90.56±0.5 | 53.18±0.3 |
| PYR400-0500 | 4x CW0500 | 119.30±0.5 | 72.57±0.3 |

### 3.2.1.2 Mounting Definition

CubeWheel Pyramid can only be mounted on its base. The pyramid base, shown in Figure 8 and dimensioned in Table 19, has eight (8) threaded mounting holes. All mounting holes **must** be used be used to ensure adequate fixation of the pyramid to the mounting structure.

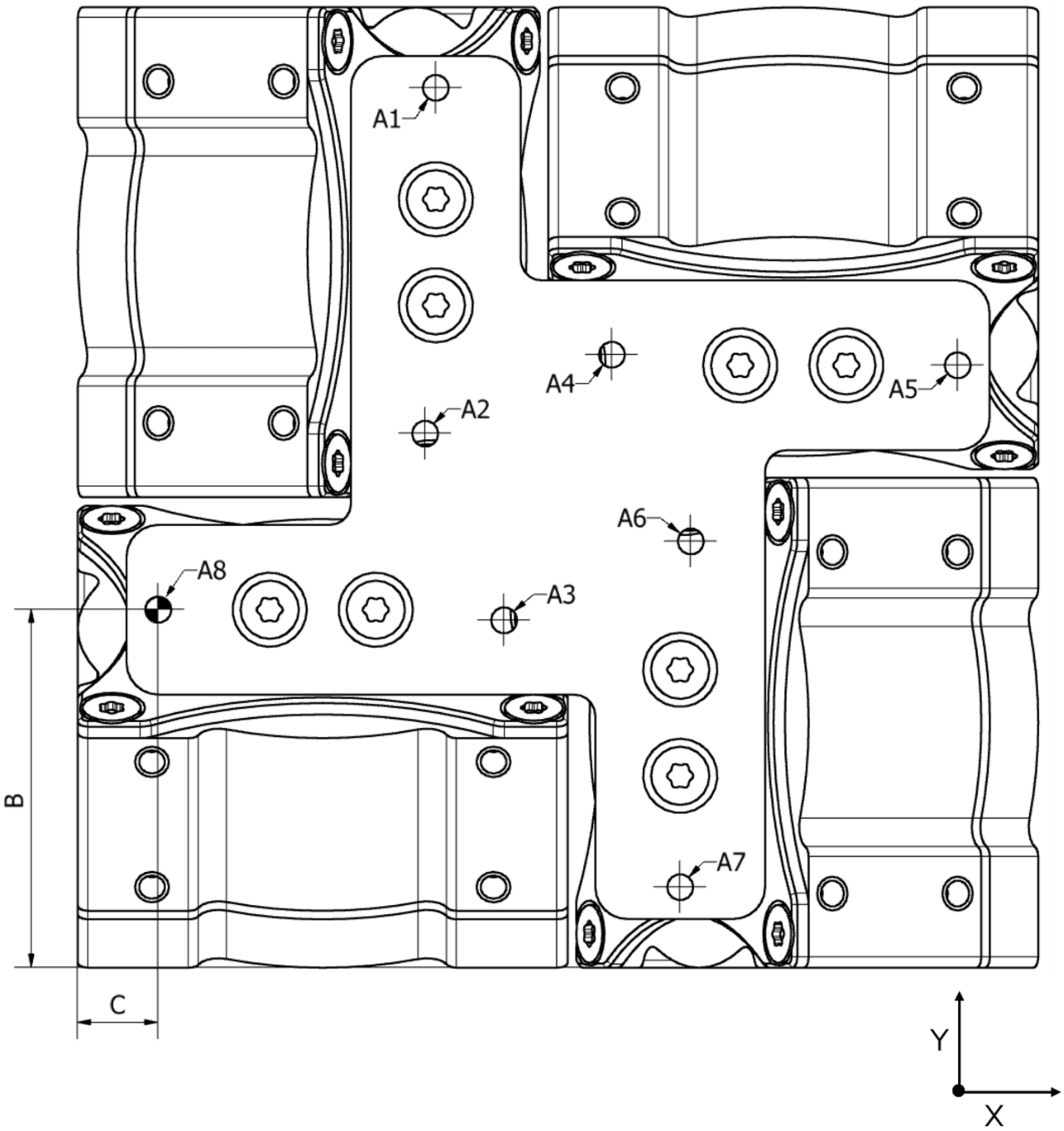


**Figure 8: Indicative Dimensions of the CubeWheel Pyramid Base**

**Table 19: CubeWheel Pyramid Base Mounting Hole Locations for Figure 8**

| Marker | CW0017P | | CW0057P | | CW0162P | | CW0500P | |
|---|---|---|---|---|---|---|---|---|
| | X dim (mm) | Y dim (mm) | X dim (mm) | Y dim (mm) | X dim (mm) | Y dim (mm) | X dim (mm) | Y dim (mm) |
| A1 | 20.35 | 38.65 | 26.48 | 40.42 | 26.16 | 49.20 | 17.21 | 72.59 |
| A2 | 20.35 | 15.65 | 24.98 | 13.92 | 25.16 | 16.60 | 17.21 | 35.79 |
| A3 | 23.00 | 0.00 | 26.50 | -1.50 | 32.60 | -1.00 | 36.80 | 0.00 |
| A4 | 36.00 | 18.30 | 40.40 | 15.43 | 42.76 | 24.04 | 53.00 | 55.38 |
| A5 | 59.00 | 18.30 | 66.90 | 13.93 | 75.36 | 23.04 | 89.80 | 55.38 |
| A6 | 38.65 | 2.65 | 41.92 | 0.02 | 50.20 | 6.44 | 72.59 | 19.59 |
| A7 | 38.65 | -20.35 | 40.42 | -26.48 | 49.20 | -26.16 | 72.59 | -17.21 |
| A8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| B | 23.00 | | 29.98 | | 33.76 | | 32.21 | |
| C | 4.00 | | 3.50 | | 7.60 | | 14.60 | |
| Hole Type | M3x0.5 5mm Deep | | M3x0.5 4mm Deep | | M3x0.5 5mm Deep | | M4x0.7 10mm Deep | |
| All dimensions have a tolerance of ± 0.1 mm unless otherwise specified. | | | | | | | | |

**Table 20: Recommended Pyramid Mounting Screw Torques**

| Product | Mounting Hole | Recommended Torque [cN.m] |
|---|---|---|
| PYR400-0017, PYR400-0057, PYR400-0162 | M3 threaded aluminium. | 87 |
| PYR400-0500 | M4 threaded aluminium. | 207 |

#### 3.2.1.3 Mass, CoM and Inertia

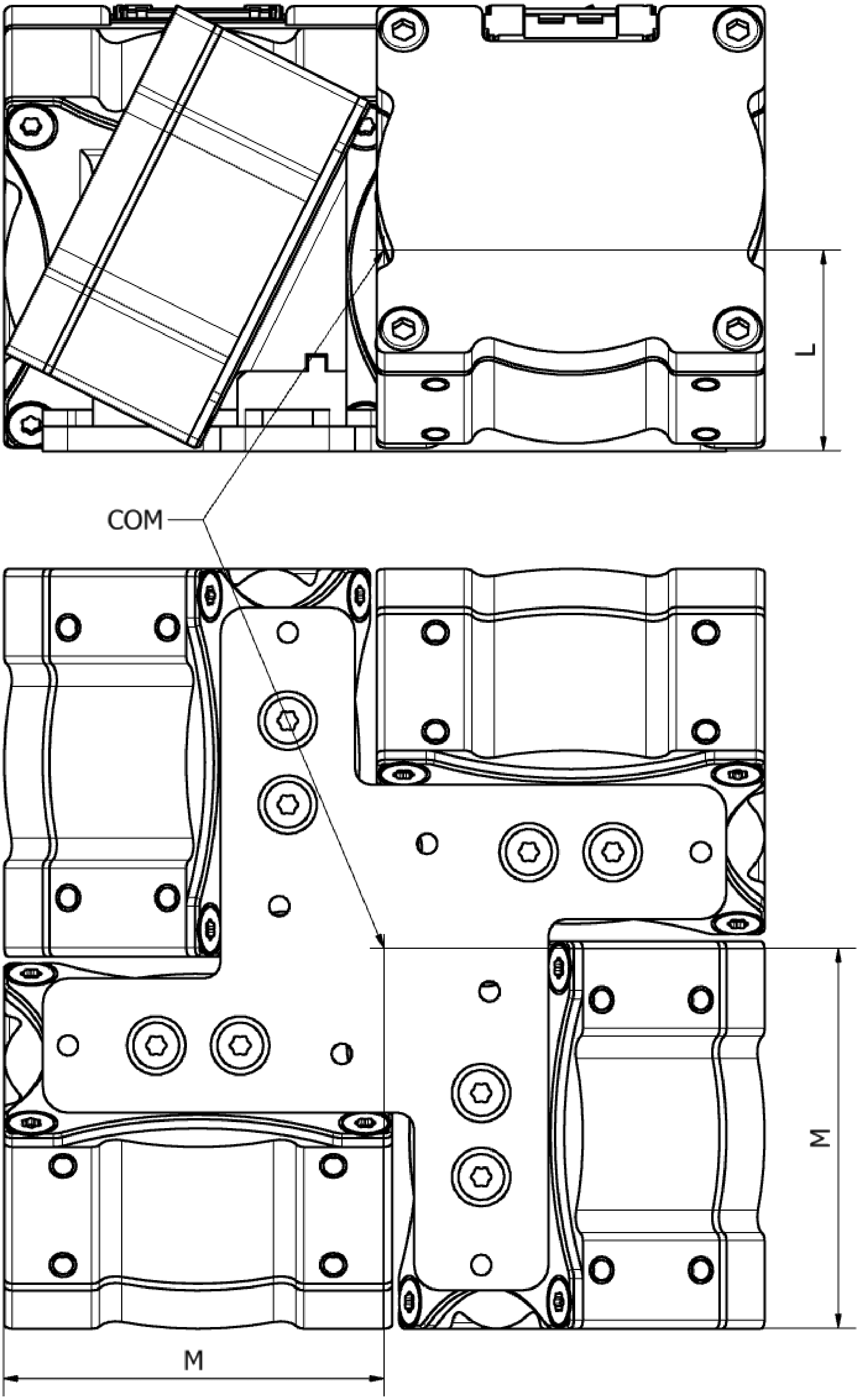


**Figure 9: CubeWheel Pyramid CoM Position**

The position of the CoM as shown in Figure 9 is given by the dimensions in Table 21.

**Table 21: CubeWheel Pyramid Mass, CoM and Inertia**

| Variant | Mass (g) | CoM (mm) | | Inertia around CoM ($gmm^2$) | | |
|---|---|---|---|---|---|---|
| | | L | M | $I_{xx}$ | $I_{yy}$ | $I_{zz}$ |
| PYR400-0017 | 236* | 17.56 | 33.50 | 92623 ± 10% | 92623 ± 10% | 149070 ± 10% |
| PYR400-0057 | 470 | 18.68 | 36.95 | 224208 ± 10% | 224208 ± 10% | 360311 ± 10% |
| PYR400-0162 | 704 | 23.95 | 45.28 | 536683 ± 10% | 536683 ± 10% | 828492 ± 10% |
| PYR400-0500 | 1424 | 35.107 | 59.50 | 2036996 ± 10% | 2036996 ± 10% | 3070937 ± 10% |

### *3.2.1.4 Coordinate System Definition*

The coordinate system definition used by the CubeWheel pyramid is shown in Figure 10. The individual reaction wheels (shown by the red letters A, B, C, D) also have their locations engraved onto the pyramid bracket.

When the pyramid is used with a CubeSpace ADCS, the CubeComputer configuration is typically set up in a manner that RWL0, 1, 2, 3 refers to wheel “A”, “B”, “C”,” D”, respectively.

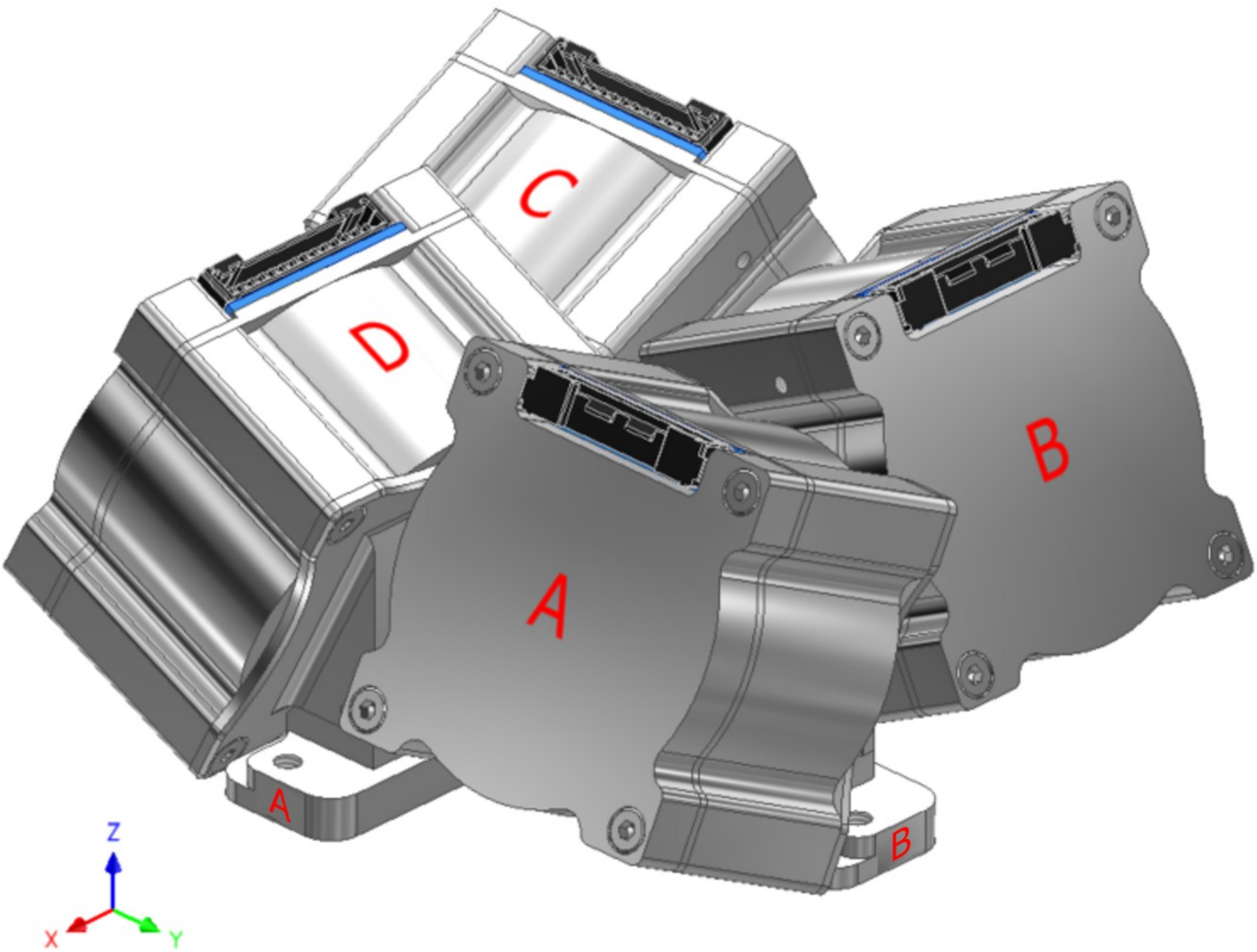


**Figure 10: CubeWheel Pyramid Coordinate System Definition**

### 3.2.2 CubeWheel Pyramid, PYR410 (Isolated)

#### 3.2.2.1 Outer Dimensions

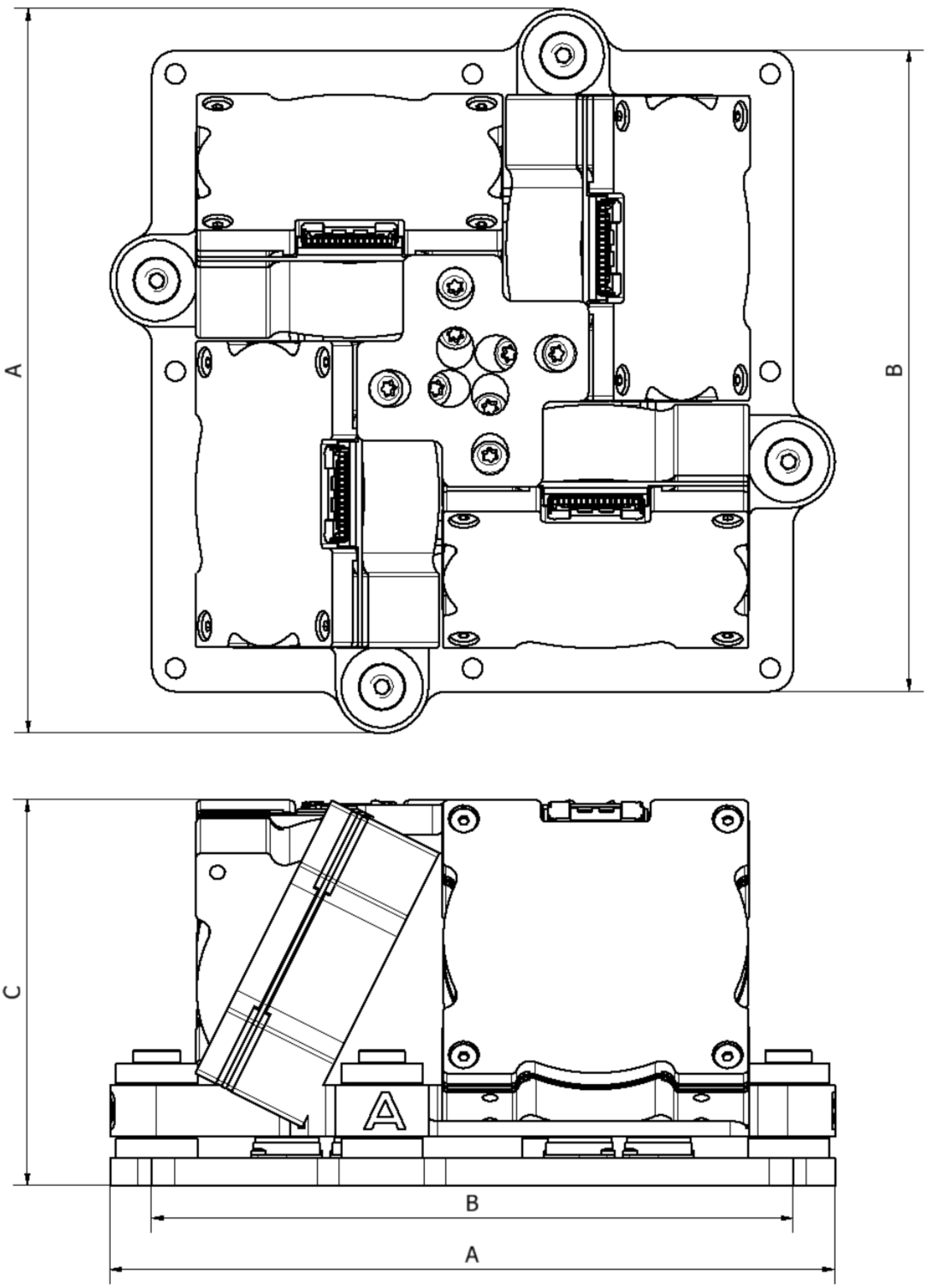


**Figure 11: Indicative Dimensions of a CubeWheel Isolated Pyramid Assembly**

The dimensions shown in Figure 7 for each Isolated CubeWheel pyramid configuration are provided in Table 18.

**Table 22: CubeWheel Isolated Pyramid Dimensions**

| Pyramid Model | Reaction Wheels | A (mm) | B (mm) | C (mm) |
|---|---|---|---|---|
| PYR410-500 | 4x CW0500 | 156.00 ±0.5 | 138.00 ±0.5 | 83.12 ±0.5 |

### *3.2.2.2 Mounting Definition*

Isolated CubeWheel pyramid can only be mounted on its base. The pyramid base, shown in Figure 8 and dimensioned in Table 19, has eight (8) mounting thru holes. All mounting holes **must** be used be used to ensure adequate fixation of the pyramid to the mounting structure.

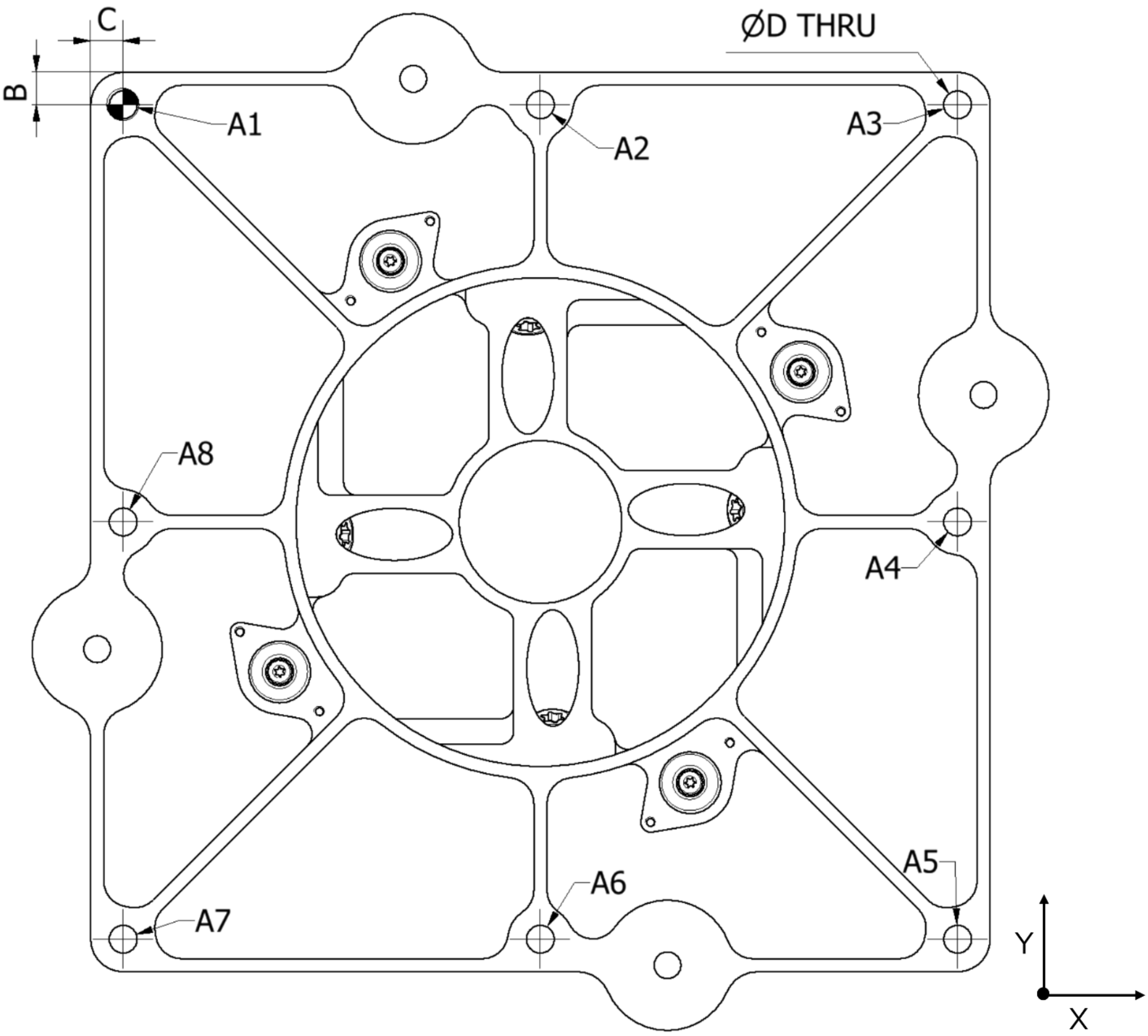


**Figure 12: Indicative Dimensions of the CubeWheel Isolated Pyramid Base**

| Marker | PYR410-0500 | |
|---|---|---|
| | X dim (mm) | Y dim (mm) |
| A1 | 0.00 | 0.00 |
| A2 | 64.00 | 0.00 |
| A3 | 128.00 | 0.00 |
| A4 | 128.00 | -64.00 |



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| Marker | PYR410-0500 | |
|---|---|---|
| | X dim (mm) | Y dim (mm) |
| A5 | 128.00 | -128.00 |
| A6 | 64.00 | -128.00 |
| A7 | 0.00 | -128.00 |
| A8 | 0.00 | -64.00 |
| B | 5.00 | |
| C | 5.00 | |
| Hole Type<br>D | 4.30<br>Thru | |



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*3.2.2.3 Mass, CoM and Inertia*

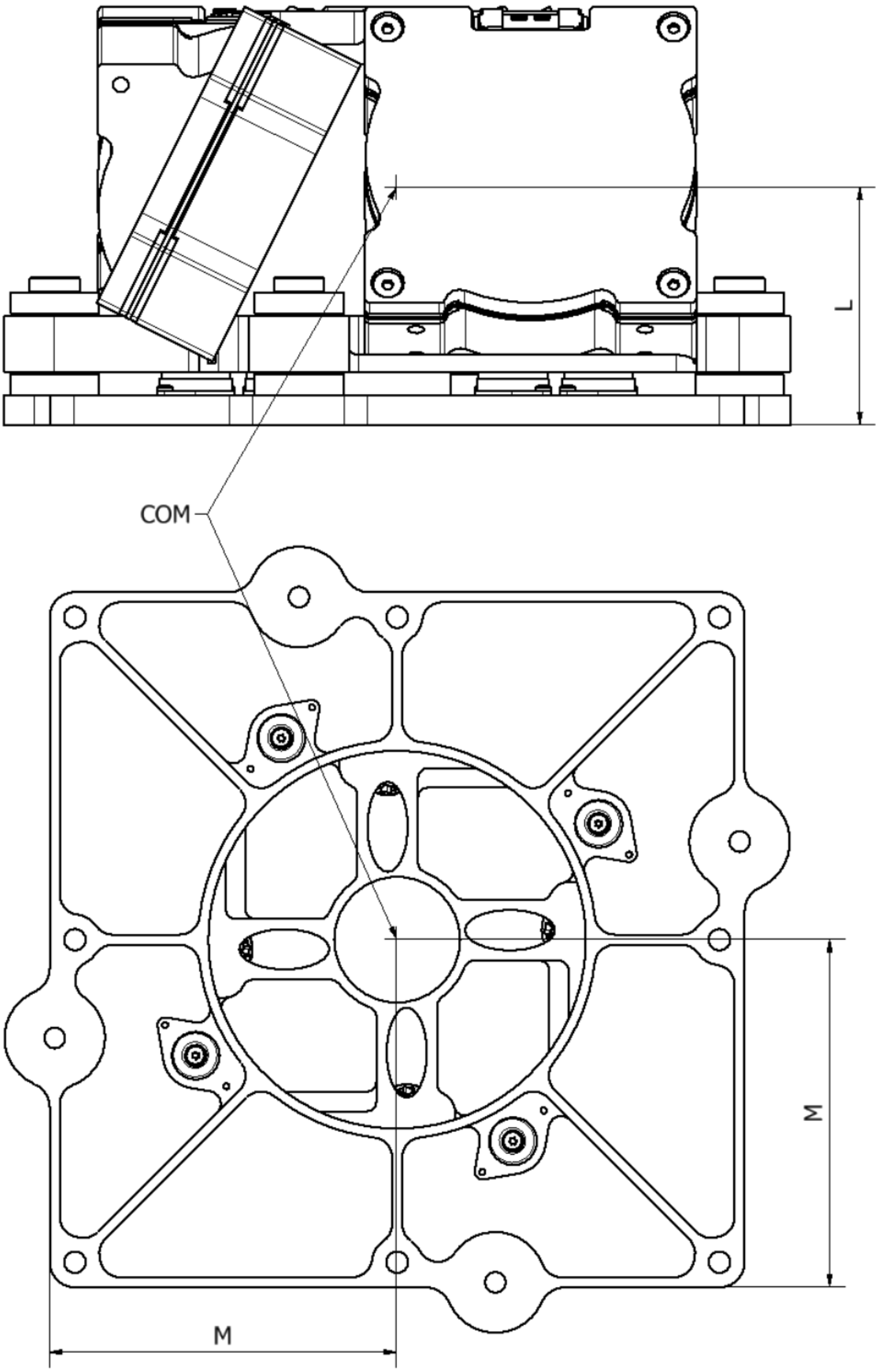


**Figure 13: CubeWheel Isolated Pyramid CoM position**

The position of the CoM as shown in Figure 9 is given by the dimensions in Table 21.

**Table 23: CubeWheel Pyramid Mass, CoM and Inertia**

| Variant | Mass (g) | CoM (mm) | | Inertia around CoM ($gmm^2$) | | |
|---|---|---|---|---|---|---|
| | | L | M | $I_{xx}$ | $I_{yy}$ | $I_{zz}$ |
| PYR410-0500 | 1649 | 47.20 | 69.00 | 2725451 ± 10% | 2725451 ± 10% | 3985951 ± 10% |

### *3.2.2.4 Coordinate System Definition*

The coordinate system definition used by the Isolated CubeWheel pyramid is shown in Figure 10. The individual reaction wheels (shown by the red letters A, B, C, D) also have their locations engraved onto the pyramid bracket.

When the pyramid is used with a CubeSpace ADCS, the CubeComputer configuration is typically set up in a manner that RWL0, 1, 2, 3 refers to wheel "A", "B", "C"," D", respectively.

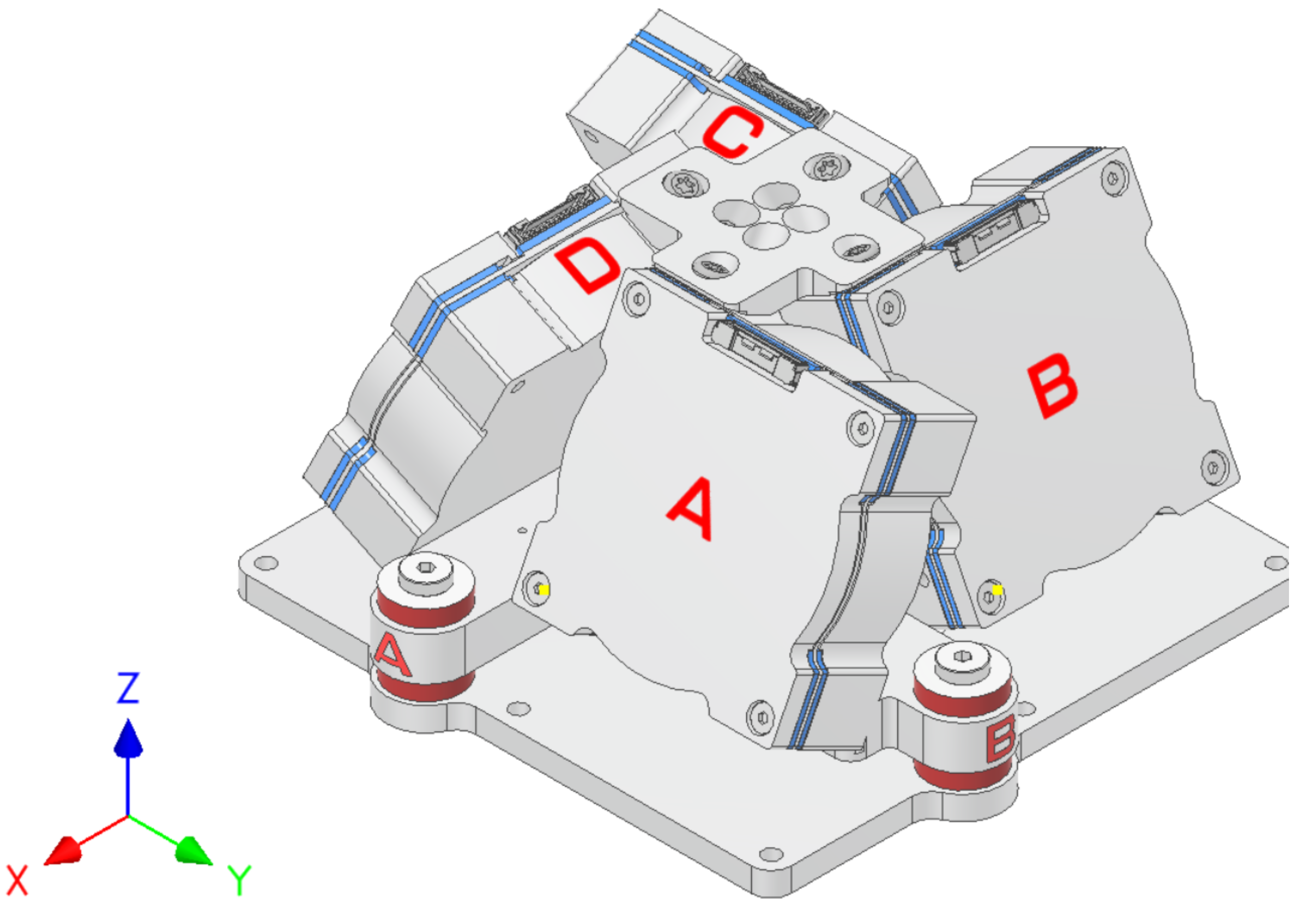


**Figure 14: CubeWheel Isolated Pyramid Coordinate System Definition**

# 4. Software Interface

Each CubeProduct is accompanied by a user manual [RD2] that provides detail regarding simple telemetry exchanges using ground support equipment. For further details regarding software interface and control, please refer to firmware reference manual [RD5].

# 5. EMI / EMC

## 5.1 Potential RF Emitter List

**Table 24: Potential Emitters**

| Component | Frequency/Bit Rate | Frequency Stability |
|---|---|---|
| MCU | 24 MHz | ± 50 ppm |
| Comms UART | 921600 Baud | ± 50 ppm |
| Comms I2C | 100 kHz | ± 50 ppm |
| Comms CAN | 1Mb/s | ± 50 ppm |
| SPI | 24 MHz | ± 50 ppm |
| Motor driver PWM | 6 kHz | ± 50 ppm |
| Motor Driver oscillator 1 | 51.5 kHz | ± 10 kHz |
| Motor Driver oscillator 2 | 103 kHz | ± 21 kHz |

## 5.2 EMI / EMC Cleanliness

### *5.2.1 Mounting Proximity Considerations regarding Magnetic Influence*

CubeWheels have MuMetal to shield the rest of the satellite from the strong magnets inside the electrical motors of the wheel. This shielding significantly warps close proximity magnetic fields; therefore, it should not be mounted within 15cm of the magnetometer and 4cm of the magnetorquers.

Table 25 summarizes the magnetic influence of a rotating CubeWheel at a set distance, further information and illustrations can be found in the technical reference manual [RD3].

**Table 25: CubeWheel Magnetic Influence**

| Model | Magnetic Influence [nT] | Distance from Sensor [cm] |
|---|---|---|
| CW0017 | 1550 ± 10% | 5 |
| CW0057 | 2100 ± 10% | 5 |
| CW0162 | 2100 ± 10% | 5 |
| CW0500 | 1600 ± 10% | 10 |

These dipoles may cause disturbances on sensitive sensor payloads and therefore should be placed as far as possible from such sensors.

### *5.2.2 Grounding*

The enclosure and mechanical parts of CubeWheel are connected to the power and signal ground through a filter designed to minimise EMI, as illustrated in Figure 15. The enclosure of CubeWheel can be grounded by the user if desired.

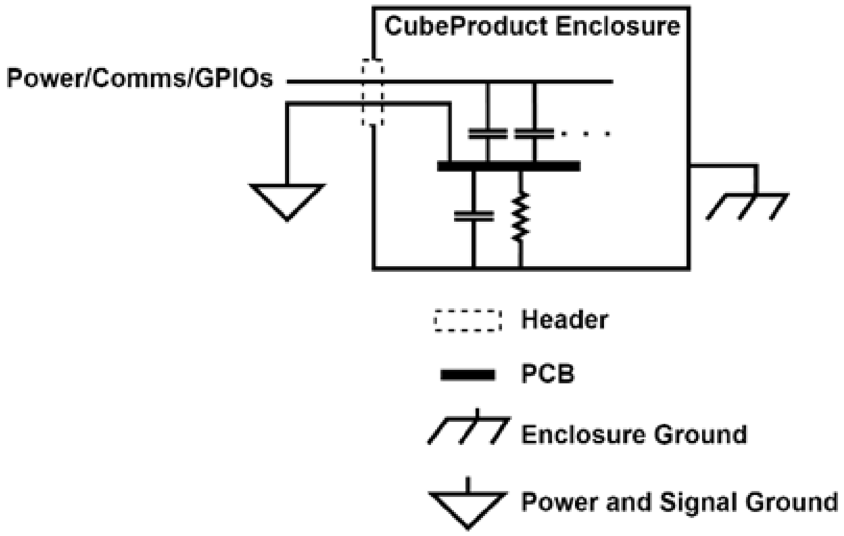


**Figure 15: Generic Grounding Diagram**

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 enclosures are directly connected to the ground introduces the risk that shorts could occur during satellite integration.

In some cases a customer might require the enclosure of CubeWheel 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.

### 5.2.3 Shielding

Shielding of the CubeWheel 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 section 5.2.1.

### 5.2.4 Filtering and Suppression

#### 5.2.4.1 Implementation on CubeWheel

The following noise filtering strategies are implemented on CubeWheel itself:

- All pins that are externally exposed through headers are filtered by way of 100pF decoupling to power and signal ground as shown in Figure 15: Generic Grounding .
- RC filtering is applied on the CAN, UART and I2C communication interfaces to minimize spurious frequencies above 1 MHz.

#### 5.2.4.2 Considerations for ADCS / OBS

As part of a CubeADCS solution, the ADCS CubeComputer implements the following filtering to reduce any noise seen or introduced:

- LC filtering on the 3.3 V supply and the boot- and enable lines to CubeWheel
- Common-mode filtering on the CAN communication interface to CubeWheel
- Filtering on the satellite battery supply

For any standalone CubeWheel, similar filtering should be implemented on the client ADCS / OBC.