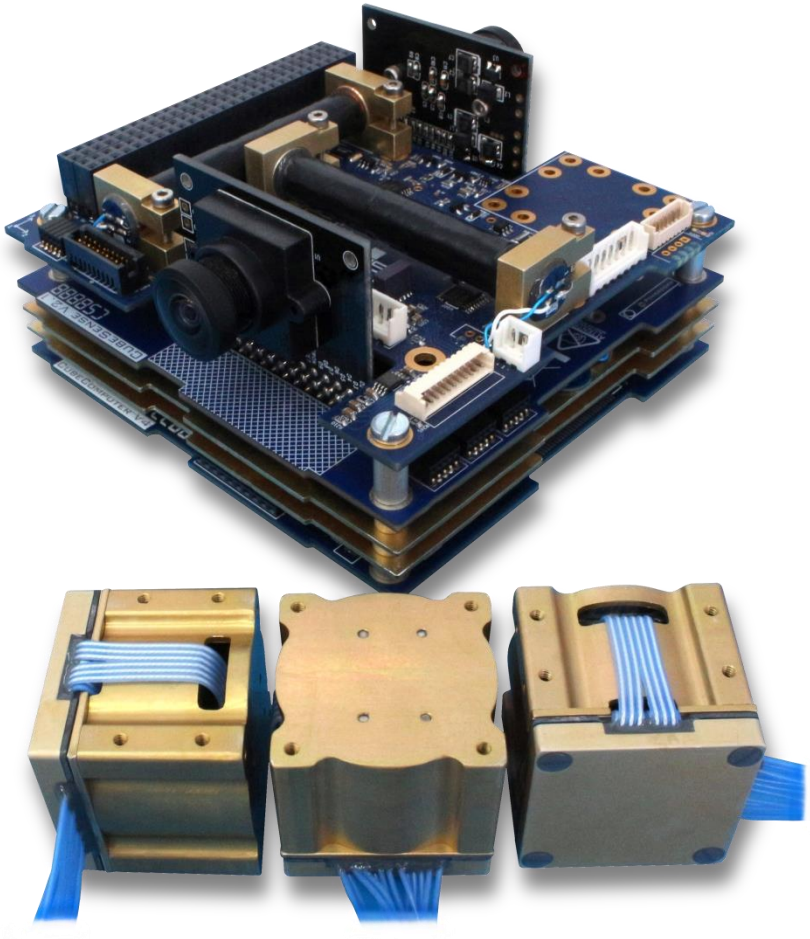
CubeADCS 3-Axis

The complete ADCS solution for 3-axis control



Hardware Configuration Sheet

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List of Acronyms/Abbreviations

ACP	ADCS Control Program
ADCS	Attitude Determination and Control System
CSS	Coarse Sun Sensor
ESD	Electrostatic Discharge
I^2C	Inter-Integrated Circuit
MCU	Microcontroller Unit
OBC	Onboard Computer
PCB	Printed Circuit Board
RTC	Real-Time Clock
SPI	Serial Peripheral Interface
TC	Telecommand
TLM	Telemetry
UART	Universal Asynchronous Receiver/Transmitter

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Client Information

Company/Institution	
Physical address	
Contact person	
E-mail address	
Date	

Satellite Information

Name of satellite	
Size (e.g. 3U)	
Orbit	
Deployable structures	
Nominal battery voltage	

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Introduction

CubeSpace aims to simplify the complicated task of integrating an ADCS into your satellite design. Our systems are therefore highly configurable, and this document allows you to customise your CubeADCS unit to meet your requirements. If additional customisation is required, please contact CubeSpace directly at info@cubespace.co.za.

The CubeADCS 3-Axis bundle is an integrated collection of CubeSpace ADCS components which provides the necessary actuators and sensors for a nanosatellite to achieve a stabilised attitude with 3-axis control.

Figure 1 provides a high-level system diagram of the complete CubeADCS 3-Axis solution.

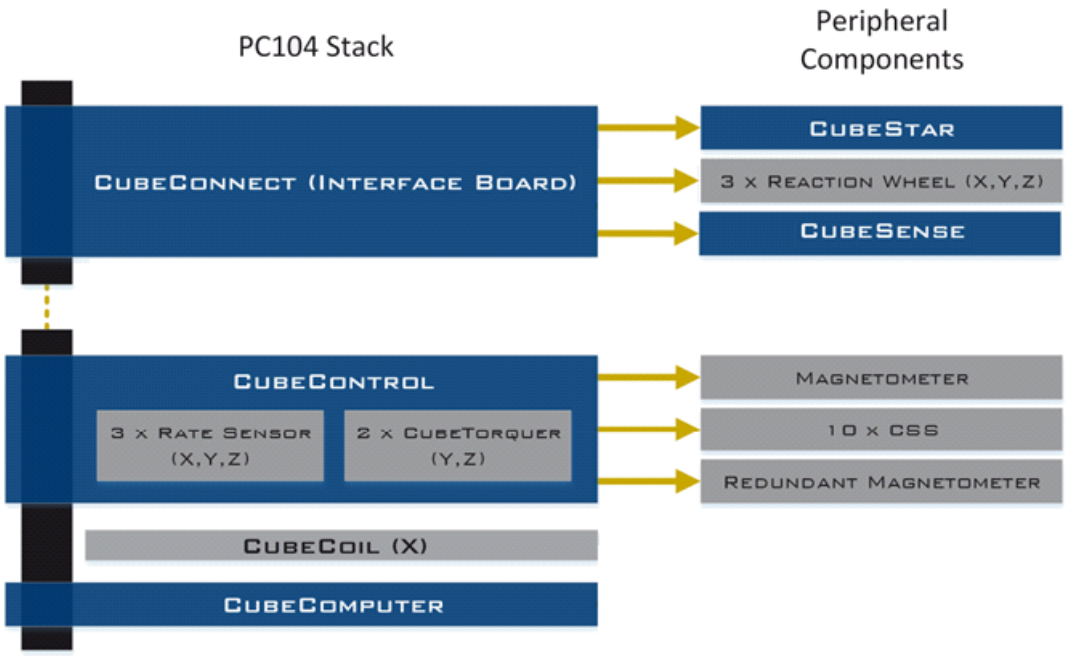

Figure 1 – System diagram of CubeADCS 3-Axis solution

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Hardware Configuration

Please complete all the relevant sections below to configure the CubeADCS unit.

1. PC104 bus configuration

The options in this section will determine the pin configuration of the main PC104 bus. The pin description of the PC104 bus, as used by the CubeADCS 3-Axis unit, is shown in Figure 2.

H2	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52
	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51
H1	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52
	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51

PC104 interface pins					
Communication					
	H1	1	CANL	CAN bus low	*option*
	H1	3	CANH	CAN bus high	*option*
	H1	21	I2C_SCL_ADCS	Internal I2C clock for all ADCS modules	required
	H1	23	I2C_SDA_ADCS	Internal I2C data for all ADCS modules	required
	H1	41	I2C_SDA_SYS	System I2C data for CubeComputer	required
	H1	43	I2C_SCL_SYS	System I2C clock for CubeComputer	required
	H1	17, 18, 19, 20	UART_1	Usable pins for UART_1 (RX or TX)	*option*
	H2	21, 22	UART_1	Usable pins for UART_1 (RX or TX)	*option*
	H1	33, 35, 39, 40	UART_2	Usable pins for UART_2 (RX or TX)	*option*
	H1	29	SPI_CLK	SPI Clock	*option*
	H1	30, 31	SPI_MOSI / MISO	SPI MOSI or MISO	*option*
	H1	32	SPI_CS	SPI Chip Select	*option*
Power					
	H2	29, 30, 32	GND	Ground connection for all modules	required
	H2	45, 46	V_Bat	Battery voltage bus	required
	H2	25, 26	5V_Main	Main 5 V supply	*standard option*
	H2	27, 28	3V3_Main	Main 3.3 V supply	*standard option*
	H1	47, 49, 51	5V_S	Switched 5 V supply options	*option*
	H1	48, 50, 52	3V3_S	Switched 3.3 V supply options	*option*
	H1	42	BUVIN	CubeComputer optional backup power supply	*option*
Internal ADCS pins					
	H1	2, 4, 6, 8, 11	ENABLE	Enable lines for CubeADCS modules position 1	*standard option*
	H1	16	ENABLE	Enable lines for CubeADCS modules position 2	*option*
	H2	17, 18, 19, 20			
	H1	5, 7, 9	ENABLE	Enable lines for CubeWheel 1 - 3	*option*
	H1	13, 14, 15	ENABLE	GPIO/ ADC or Enable Lines	*option*
	H1	10	ENABLE	Enable Line for CubeStar position 1	*option*
	H2	15	ENABLE	Enable Line for CubeStar position 2	*option*

Figure 2 – PC104 bus pin description

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1.1. Power supply

The CubeADCS unit requires 3.3 V, 5 V, and the battery voltage to operate. CubeComputer can however be powered by a separate 3.3 V supply, as specified in Option 7. Please select the 3.3 V and 5 V supplies for the ADCS bundle and CubeWheels on the PC104 header, in Option 1 and Option 2. *(Standard option: 3.3 V = H1-48 and 5 V = H1-47)*

Option 1 – 3.3 V supply

	H2-27,28	H1-48	H1-50	H1-52
3.3 V supply pin(s)				

Option 2 – 5 V supply

	H2-25,26	H1-47	H1-49	H1-51
5 V supply pin(s)				

The gains of the speed controller on the MCU of a CubeWheel unit are dependent on the battery bus voltage of the satellite. Please specify the expected nominal battery voltage. *(Standard option: 8.0 V)*

Option 3 – Battery bus voltage

	8.0 V	Other (specify)
Raw battery voltage		

1.2. UART

The CubeADCS bundle has two UART buses, designated UART 1 and UART 2, which can be used to interface with the bundle. Both buses are routed to the PC104 header. UART 1 is also accessible from the debug header on CubeComputer. Please select to which PC104 pins the UART must be connected, if any. *(Standard option: None)*

Option 4 – UART 1

	H1-17	H1-18	H1-19	H1-20	H2-21	H2-22	None
UART 1 TX							
UART 1 RX							

Option 5 – UART 2

	H1-33	H1-35	H1-39	H1-40	None
UART 2 TX					
UART 2 RX					

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1.3. CubeADCS enable lines

The CubeADCS bundle requires pins on the PC104 header to enable/disable its various subcomponents. Please select the locations these lines can occupy on the PC104 header. The locations of these pins are visualized on page 7 in Figure 2.

Note: The CubeStar and CubeWheel enable pins *only* need to be selected if these components are part of the CubeADCS.

Option 6 – Enable pins location on PC104

Component	Enable Pin	✓	Enable Pin	✓
CubeSense 1	H1 – 2		H2 – 20	
CubeSense 2	H1 – 11		H1 – 16	
CubeControl Common	H1 – 4		H2 – 19	
CubeControl Motor	H1 – 6		H2 – 17	
CubeControl Signal	H1 – 8		H2 – 18	
CubeStar	H1 – 10		H2 – 15	
Reaction Wheel 1 *	H1 – 5		H1 – 13	
Reaction Wheel 2 *	H1 – 7		H1 – 14	
Reaction Wheel 3 *	H1 – 9		H1 – 15	

2. CubeComputer configuration

2.1. Power supply (main OBC)

It is possible to have only CubeComputer on one 3.3 V bus and the other ADCS components on another 3.3 V supply selected in Option 1. Please select the 3.3 V supply for CubeComputer.

Option 7 – CubeComputer power supply

	H2-27,28	H1-48	H1-50	H1-52
CubeComputer 3.3 V supply				

2.2. CAN

CubeComputer contains optional CAN electronics which allows the user to interface with the CubeADCS unit via a CAN bus. If the CAN interface is not required, CubeComputer's power consumption can be reduced slightly by leaving the CAN electronics unpopulated. Please indicate whether the CAN bus will be required. *(Standard option: No)*

Option 8 – CAN bus on CubeComputer

	Yes	No
CAN controller and transceiver		

In the case where a CAN controller and transceiver is required, please specify if a termination resistor is required and what the resistance of this resistor should be.

Option 9 – CAN termination resistor

	120Ω	other	No resistor
CAN termination resistor			

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3. CubeSense configuration

3.1. Camera sensor type

Each CubeSense can, during fabrication, be configured to be either a sun sensor or nadir sensor. Please select the type of sensor for Camera 1 and Camera 2. *(Standard option: Camera 1 = Nadir, Camera 2 = Sun).*

Option 10 – Camera type

Camera Number	Sun	Nadir
CubeSense 1		
CubeSense 2		

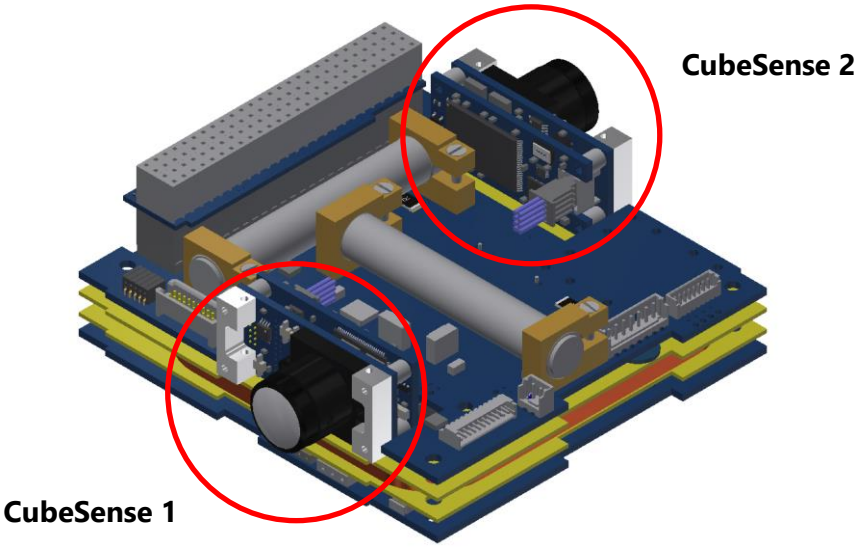

Figure 3 – CubeSense camera sensor location.

3.2. Camera sensor mounting

The CubeSenses. should be mounted against the satellite's side-panel, **which the user is responsible for**. CubeSense then connects to the CubeComputer via the CubeConnect interface board (see Figure 1). An 8-way harness is used to connect CubeSense to the CubeConnect. Please indicate the desired CubeSense harness length.

Option 11 – CubeSense Harness Length

	Standard (150mm)	Other (max 300mm)
CubeSense 1		
CubeSense 2		

4. CubeControl configuration

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4.1. Coarse sun sensors

CubeControl interfaces with a Coarse Sun sensor (CSS) array consisting of up to ten photodiode sensors. These sensors are connected to CubeControl through a Molex PicoBlade 2-way in-line connector (L1).

There are two main configurations in which these CSSs' photodiodes can be attached to the satellite:

1. **Default option** – the photodiodes are individually soldered onto small 10x4.5mm PCBs (see Figure 4) which include PicoBlade connectors on a harness (L2). The photodiode PCBs are then typically epoxied onto the satellite's side-panel. An example of this configuration is shown in Figure 5.

Figure 4 – Example of photodiode soldered onto small PCB

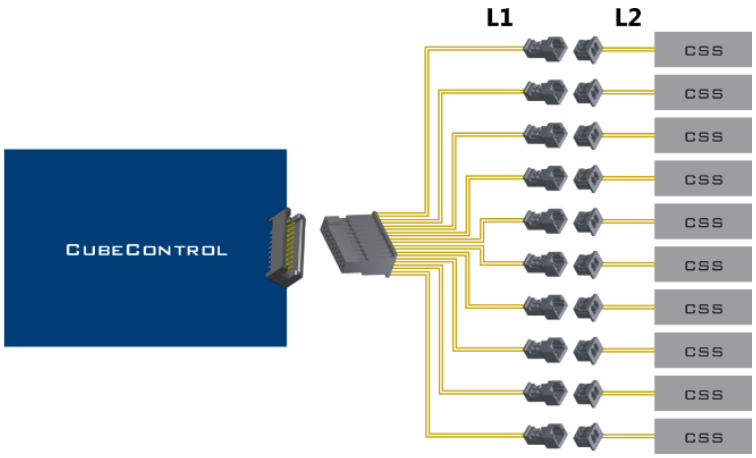

Figure 5 – Coarse Sun Sensor wiring for Option 1 (default)

2. **Self-assembly option** - only the Photodiodes, PicoBlade connectors and harness L1 (360 mm, uncrimped) are supplied, for own assembly by the client. This smaller-sized configuration is useful if the solar-panels have dedicated pads for photodiodes. An example of this configuration can be seen in Figure 6.

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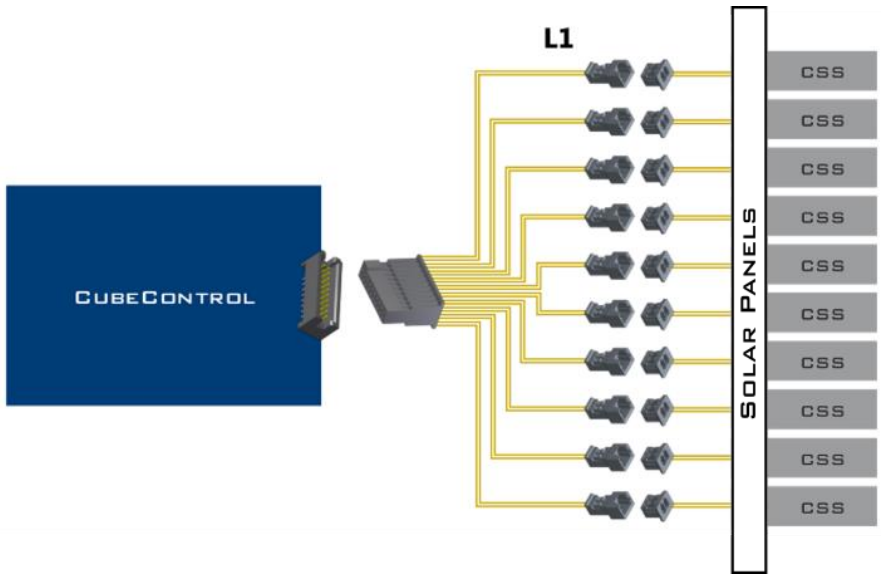

Figure 6 – Coarse Sun Sensor wiring for Option 2 (self-assembly)

L1 harness length is configurable with a standard length of 300 mm and a maximum length of 350 mm. L2 harness length is provided in a standard length of 50 mm.

Please choose the desired CSS configuration, as well is the L1 harness length.

Option 12 – Coarse Sun Sensor Option.

	Option 1 (Default)	Option 2 (Self-assembly)
CSS configuration option		

Option 13 – Coarse Sun Sensor Harness Lengths.

This table is only applicable if CSS Option 1 is selected.

L1 Harness Lengths	L1 Length (mm)	
	Standard (300 mm)	Other (max 350 mm)
CSS 1		
CSS 2		
CSS 3		
CSS 4		
CSS 5		
CSS 6		
CSS 7		
CSS 8		
CSS 9		
CSS 10		

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4.2. Primary magnetometer

CubeControl interfaces with the external magnetometer using an Omnetics Nano Circular 11-way in-line connector set. The harness is terminated in an 11-way Molex PicoBlade female connector. An illustration of the magnetometer connection can be seen in Figure 7.

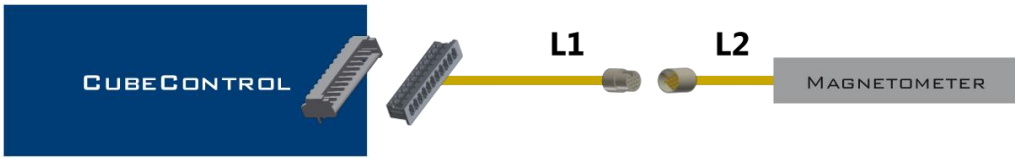

Figure 7 – Magnetometer wiring diagram

The length of the harness on CubeControl's side of the in-line connector (L1 in Figure 7) can be configured. The maximum length of L1 is 350 mm. The length of L2 is 50 mm. Please indicate the desired magnetometer harness length. *(Standard option: L1 = 300 mm)*

Option 14 – Magnetometer harness length

	L1 (mm)
Magnetometer harness length	

The primary magnetometer can be attached to a small boom which is deployed via a telecommand. The boom separates the magnetometer 8 cm from the satellite body, limiting the effect of electromagnetic interference and lowering the measurement noise. **It is strongly recommended that the magnetometer should be deployable.** Please select whether the magnetometer should be deployable. *(Standard option: Deployable)*

Option 15 – Deployable magnetometer

	Deployable	Not deployable
Magnetometer configuration		

4.3. Redundant magnetometer

This section is only applicable if an optional redundant magnetometer is included in the ADCS solution.

CubeControl can interface with a second (redundant), non-deployable magnetometer. The redundant magnetometer, which is not supplied with the CubeADCS bundle by default, is connected to CubeControl by a 6-way wire harness. The maximum harness length is 400 mm. Please indicate the desired redundant magnetometer harness length. *(Standard configuration: 300 mm)*

Option 16 – Redundant magnetometer harness length

	300 mm	Other (specify)
Redundant magnetometer harness		

4.4. Magnetic torquers

CubeControl can interface with three magnetic torquers, two of which are CubeTorquer rods mounted on CubeControl. The third magnetic torquer can either be an air-core CubeCoil located between CubeComputer and CubeSense or a loose CubeTorquer rod. The loose rod connects to CubeControl with a 2-way wire harness and Molex PicoBlade connector set. The maximum harness length is 300 mm. Please select the desired configuration for the third magnetic torquer. *(Standard option: CubeCoil)*

Option 17 – Third magnetic torquer

	CubeCoil	CubeTorquer rod (specify harness length)
Third magnetic torquer		

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5. CubeWheel configuration

The CubeWheels needs to be connected to the PC104 header. To do this CubeSpace provides a PCB called the CubeConnect. The CubeConnect comes in two forms. The Standard-CubeConnect and the micro-CubeConnect.

The Standard CubeConnect is shown in Figure 8. It is a full CubeSat PC104 PCB with headers which can be used to connect the CubeWheels to the PC104 headers. It can also be used as a mounting platform for 3 CubeWheel Small units as shown in Figure 8. The harness length is not customizable for all the CubeWheel sizes. The only harness length which is customizable is the length of the CubeWheel **small** harness when the wheels are not mounted on the Standard CubeConnect and only in the case where a standard CubeConnect is used (and not the micro CubeConnect).

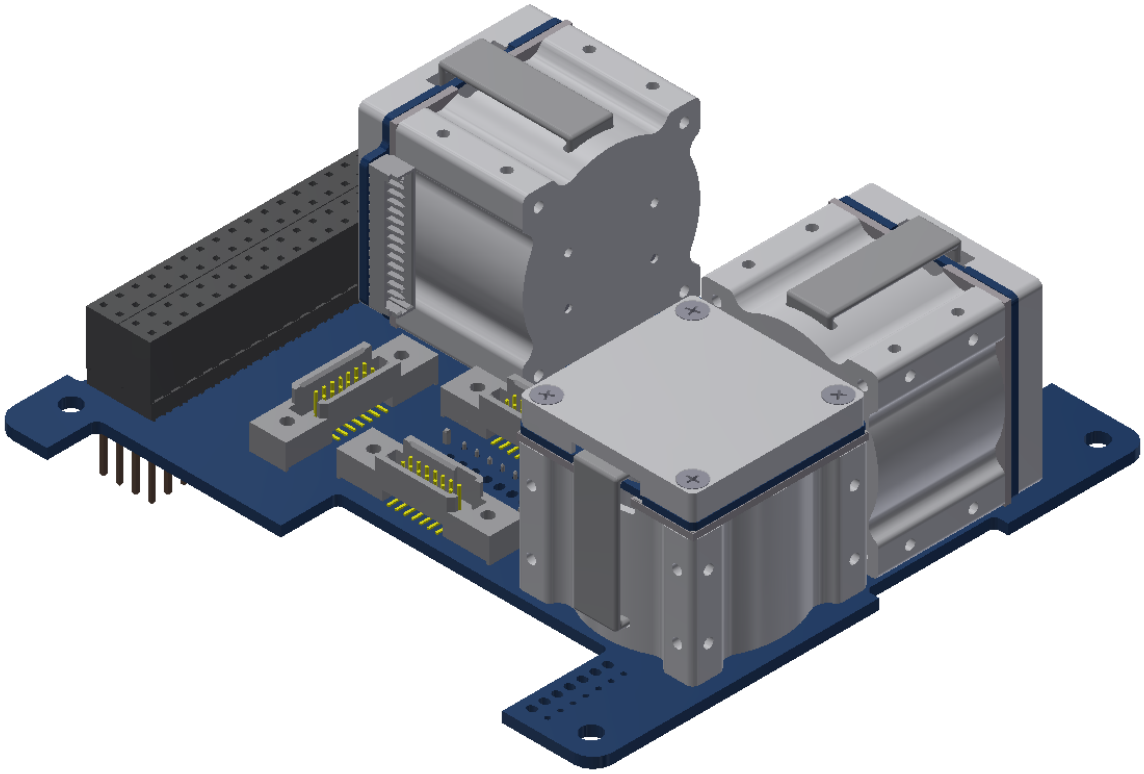

Figure 8 – Standard CubeConnect

The micro-CubeConnect shown in Figure 9 is a small PCB housing the PC104 header. The harnesses to the wheels are soldered directly into this version of the CubeConnect and thus allows for the harness length to be customizable for any CubeWheel.

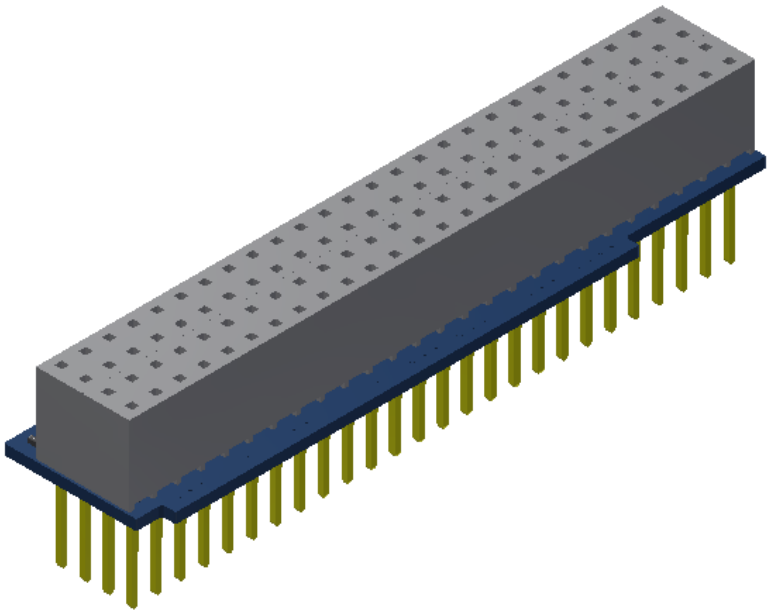

Figure 9 – Micro CubeConnect

5.1. CubeConnect

Please select which CubeConnect you would like to use for your CubeADCS:

Option 18 – CubeConnect

CubeConnect	Selection
Standard	
Micro	

The PC104 header used on the CubeConnect you chose can be selected below:

Option 19 – CubeConnect PC104 header

Samtec header model	Image	Height above PCB (mm)	Pin length below PCB (mm)	Choice (indicate with X)
SSQ-126-21-G-D		8.51	1.04	
SSQ-126-23-G-D		8.51	8.4	

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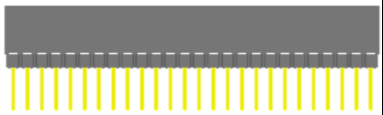
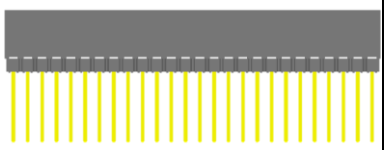
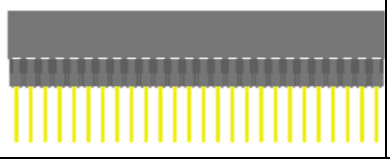
SSQ-126-04-G-D		8.51	13.23	
ESQ-126-38-G-D		11.05	5.76	
ESQ-126-39-G-D		11.05	10.59	
ESQ-126-49-G-D		13.59	8.05	

5.2. CubeWheel Small Mounting

If you have selected to make use of the Standard-CubeConnect and you are using three small CubeWheels you have the option to have the wheels mounted to your CubeConnect or not. If you are not making use of small CubeWheels with a Standard-CubeConnect please ignore this option.

Option 20 – CubeWheel Small mounting

CubeWheel Small	Selection
Mounted on Standard CubeConnect	
Provided loose with a Harness length specified in Option 22	

5.3. Harness length

If you have selected to use a microCubeConnect or loose small CubeWheels provided with a standard CubeConnect please provide the desired length of the harness between the CubeConnect and the CubeWheel. The harness can have maximum length of 300mm.

Option 21 – CubeWheel harness length

CubeWheel Harness	Length (mm) [MAX 300mm]
Length	

If you have selected to use a Standard CubeConnect with medium or large CubeWheels then a harness will be provided with a length of 230mm.

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5.4. CubeWheel housings

The aluminum housings of the CubeWheels can be connected to ground if required. Please select whether the housings should be grounded. *(Standard option: Not connected)*

Option 22 – CubeWheel housings

	Not connected	Grounded
CubeWheel housings		

Client signature: _____

6. CubeStar configuration

This section is only applicable if CubeStar is included in the ADCS solution.

CubeStar connects to CubeComputer via the CubeConnect interface board (see Figure 1). A 7-way harness connects CubeStar to CubeConnect via a HARWIN M80-8760722 L-Tek SIL connector set. **The user is responsible for mounting CubeStar.** The user must send the mounting transformation matrix relative to the satellite body coordinate frame (SBC) to CubeSpace one month prior to the delivery date. Please indicate the desired CubeStar harness length. The standard CubeStar harness Length is 150 mm, this distance can be customized up to a maximum length of 300mm if required.

Option 23 – CubeStar harness length

	150 mm [MAX 300mm]	Other (specify)
CubeStar harness length		

CubeStar can be powered from different power lines. Please select the power line CubeStar should be powered from.

Option 24 – CubeStar power line

	H2-27,28	H1-48	H1-50	H1-52
CubeStar power				

The CubeStar mounting holes and the lens holder can be connected to ground or left unconnected.

Option 25 – CubeStar grounding

	Grounded	Not Grounded
CubeStar mounting holes		
CubeStar lens and lens holder		

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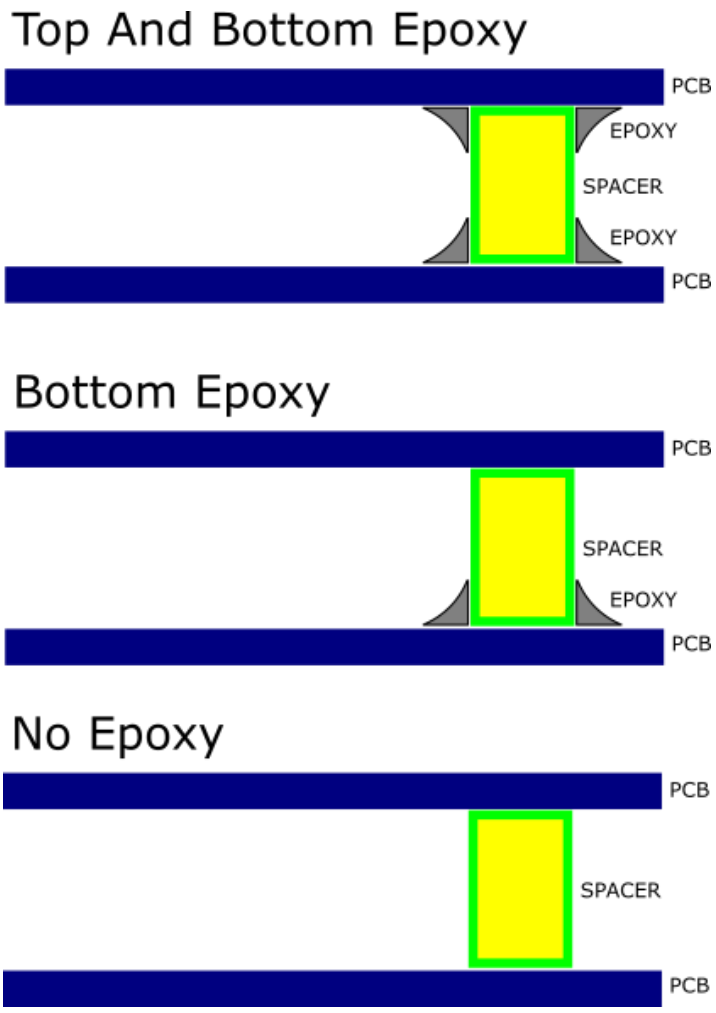
7. Assembly options

The individual components (PCBs) of the ADCS are connected to one another through the main PC104 header. For additional structural support the PCBs are supported by Aluminium spacers and kept in place by M3, A4 bolts and nuts through the mounting holes. When the ADCS is integrated with the rest of the satellite these nuts and bolts will have to be removed. This will cause the spacers to easily fall from the ADCS. To Prevent this, the spacers can be epoxied in place to insure they remain in position. (*Standard option is to have the bottom part of the spacers epoxied*)

Please specify if the spacers should be epoxied or not. Please see the images below for a visual explanation.

Option 26 – Epoxy the ADCS spacers

	Yes – Only the bottom	Yes – Top and bottom	No
Epoxy spacer			



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7.1. Mounting holes

The standard CubeSat mounting holes on the corners of the CubeADCS stack can be connected to ground if required. Please select whether to ground the mounting holes of the bundle. *(Standard option: Not connected)*

Option 27 – Grounding of mounting holes

	Not connected	Grounded
Mounting holes		

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Declaration

I, _____, hereby declare that I am a legal representative of _____.

Signature	Date

Client signature: _____

Document History

Version	Person	Pages	Date	Description of change
3.0	MK	ALL	20/03/2017	V3 First draft
3.01	MK	21, 22	01/06/2017	Remove T&C
3.02	MK	9	07/07/2017	Updated PC104 table
3.03	CJG	12	12/02/2018	Improved SPI description
3.04	CJG	12	26/05/2018	Added option for CAN termination resistor
3.05	CCH	ALL	28/05/2018	General language editing Change of document name
3.06	CJG	20	01/06/2018	Added the ADCS spacer epoxy option
3.07	CJG	11	26/07/2018	Extended description for I2C pull-up.
3.08	HW	14	28/09/2018	Added CSS mount on Solar Panel Option
3.09	HW	10	25/10/2018	Improved PC104 enable line selection.
3.10	CJG	ALL	24/01/2019	Added grounding option and performed some formatting. Moved mounting hole grounding option to assembly section
3.11	HW	14	08/02/2019	Improved CubeSense section.
3.12	HW	17	06/08/2019	Improved magnetometer harness length options
3.13	GJR, HW	12	27/09/2019	Removed SPI options from CubeComputer Updated CubeSense options Updated front page
3.14	CJG	16	15/10/2019	Removed torquer rod mounting bracket grounding option. Will always be grounded.
3.15	GJVV, JG	ALL	11/11/2019	Added enable line option for second CubeSense Fixed CubeStar grounding option title Fixed heading numbering Header spacing Some other minor cosmetic changes Clarified CSS Option 2 is supplied with harness L1 uncrimped Spilt CSS assembly option and harness lengths table into two
3.16	CJG, DGS	17-21	04/02/2020	Rewrote the CubeConnect and CubeWheel Section Add maximum CubeStar Harness Length of 300 mm.
3.17	CJG	4	28/02/2020	Fix reference error in Table of Contents

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