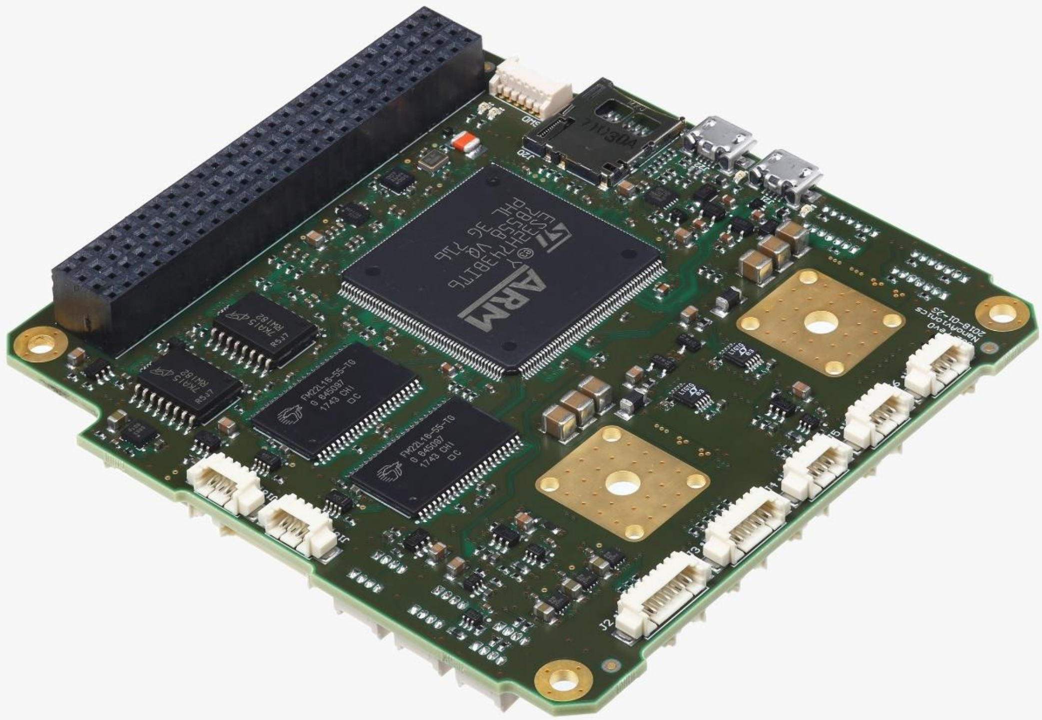

SatBus 3C2

Data Sheet

NA-SB3C2-G0-R1

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Document Revisions Traceability Sheet

Rev. 0	**Date:** 2018-11-07
Changes: Original Issue	
Rev. 1	**Date:** 2018-12-14
Changes: 5.1 table UHF modules current limit value change (hardware change) 8.1 table Additional mass data – without UHF modules	

Contents

1 Introduction

SatBus 3C2 is a highly integrated small satellite main bus unit containing advanced functionality:

- An on-board flight computer (OBC)
- An attitude determination & control system (ADCS)
- Redundant UHF communication system (COMM)

SatBus 3C2 is tailored for small-sized spacecrafts and complies with the CubeSat standard. The system is designed to save customers' time and budget, minimize required integration effort and effectively increase volume for payload as well as overall system reliability through matched hardware on one board.

SatBus 3C2 architecture is based on an STM32 H7 series microcontroller with high-performance and low power ARM Cortex™ M7 32-bit core MCU, operating at a frequency of up to 400 MHz. The same M7-core MCU performs OBC and ADCS functions. External flash and F-RAM memories provide reliable storage for telemetry and user data. A number of various digital interfaces are available for sensor and other CubeSat hardware support.

2 Highlight Features

2.1 Key Features

- Dual (Redundant) UHF Digital Radios "SAT2RF1-1D" onboard
- CubeSat Space Protocol (CSP) support
- In-orbit firmware update
- Low power consumption

2.2 Flight Computer (OBC/ADCS) Features

- Cortex-M7 core, clock speed up to 400 MHz (configurable), 200 MHz typical
- 1 MB of integrated RAM
- 2 MB of integrated FLASH memory
- 2×512 kB of FMC-connected FRAM memory
- 256 MB of external NOR-FLASH for data storage (2 × two die (64 MB each) chips, QSPI)
- 2×512 kB of FRAM (SPI) for frequently changing data storage
- microSD card support
- On-board magnetometer and three gyroscopes
- On-board magnetorquer drivers
- Multiple CAN, SPI, I2C, UART/USART interfaces
- PWM, GPIO Outputs
- Debug interfaces: USB/SWD

3 System Description

3.1 System Block Diagram

A block diagram of the system and its interfaces is provided in the figure below.

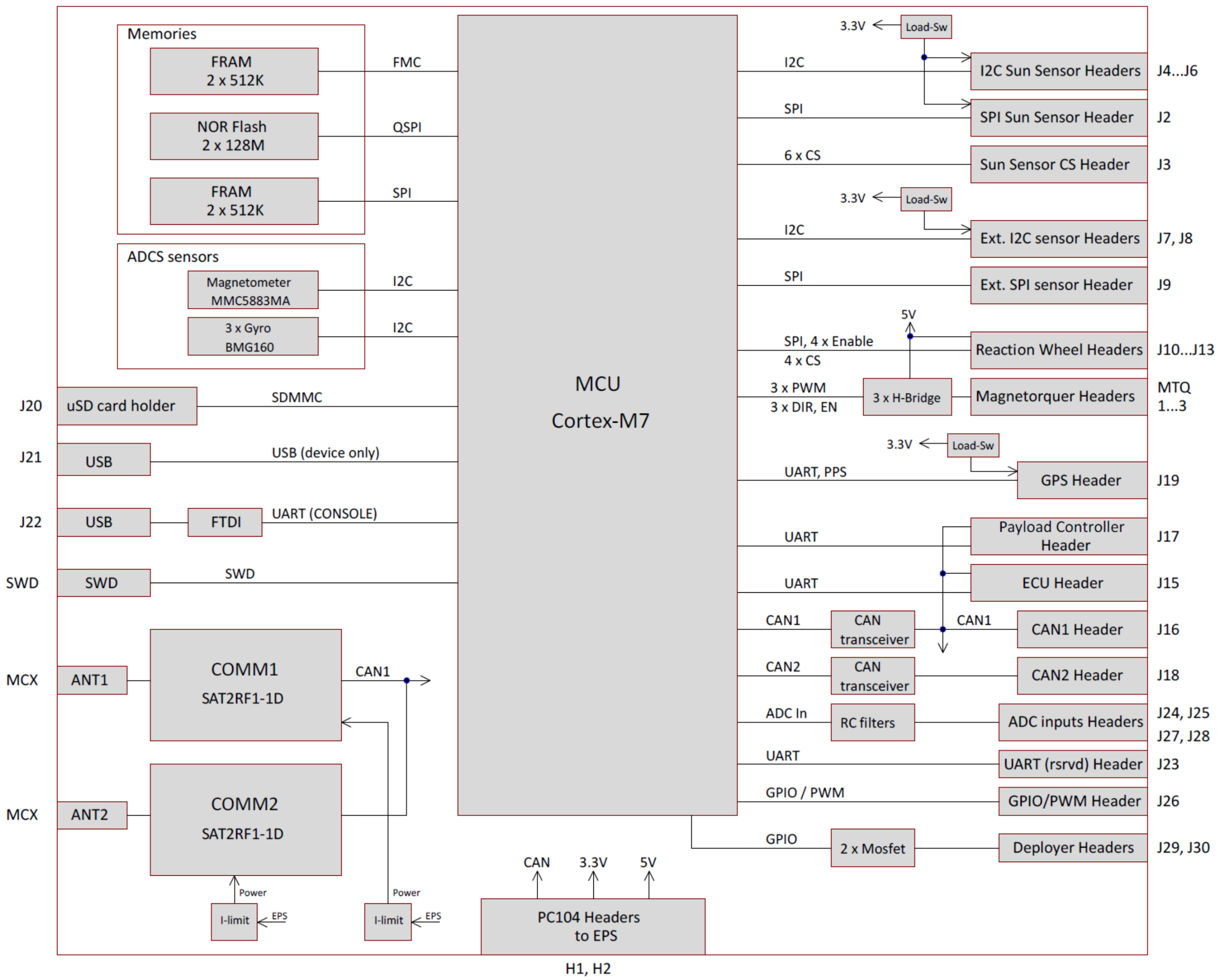

Figure 1. SatBus 3C2 Flight Computer Block Diagram

3.2 ARM Microcontroller

SatBus 3C2 architecture is based on a STM32 H7 series microcontroller with high-performance and low power ARM Cortex™ M7 32-bit core. The MCU is able to operate at a frequency up to 400 MHz and it may deliver up to 856 DMIPS computing power (Dhrystone 2.1 test). It also has double precision FPU, L1 cache (16 + 16 kBytes) and fast (parallel) memory interface.

In this design, the same M7-core MCU performs OBC and ADCS functions.

3.3 On-board Memories

Beside internal fast MCU memories, 3C2 board offers three types of external memories:

- Fast and reliable FMC connected FRAM memory (2 chips × 512 Kbytes). FRAM memory offers the highest reliability currently available in the industry (up to 10^{14} write cycles). Furthermore, it is radiation resistant. This FMC connected FRAM memory is convenient for critical image or configuration files storage
- Large QSPI connected NOR Flash memory (2 chips × 128 Mbytes). This large pool of fast and reliable SLC Flash memory is suitable for telemetry and other data storage
- Reliable SPI connected FRAM memory (2 chips × 512 Kbytes)
- microSD card interface. Suitable for non-critical, but very large data storage (log files, etc)

3.4 Redundant UHF Communication Subsystem

3C2 board is the heart of highly integrated NanoAvionics CubeSat bus. To offer highest bus integration, the 3C2 board integrates two redundant NanoAvionics 430-440 MHz or 399-403 MHz UHF radio modules "SAT2RF1-1D". Please refer to the SAT2RF1-1D datasheet regarding complete UFH module specification.

3.5 CAN Bus Interface

SatBus 3C2 board is designed to use CAN as the main system bus. As may be seen in Figure 1, UHF modules are connected to the MCU via CAN interface. Other subsystem connectors (Payload Controller, ECU) include CAN interface signals. A second CAN interface is available for auxiliary / sensor use.

3.6 On-board ADCS Sensors

SatBus 3C2 accommodates these ADCS sensors on-board:

- Three 3-axis gyroscopes
- A magnetometer

The purpose of having three gyroscopes is to increase accuracy through averaging. The gyroscopes are placed in different orientations on the board, to eliminate a possible one axis system-offset. The zero-rotation offset may also be calibrated in the software. Please refer to electrical specification section for the details.

3.7 External Sensors and Subsystem Load Switches

Also, the board has a whole range of dedicated / auxiliary interfaces for external ADCS sensors:

- I2C / SPI interface for SunSensors
- Two I2C interfaces for external magnetometers, temperature or other sensors
- SPI interface for external IMU (gyroscope) module
- Dedicated GPS (UART) interface

The board also includes dedicated load switches for the external ADCS sensors. All load switches include current protection. Please refer to the electrical specification section for details.

3.8 ADCS Actuator Interfaces

3C2 board has dedicated outputs / interfaces for the ADCS actuators:

- An integrated 3-axis magnetorquer driver (H-Bridge). The board is made to drive simple passive magnetorquer coils. The magnetorquers are PWM controlled. 3C2 board is also able to measure voltage and current of the magnetorquers
- Reaction Wheels (SPI) interface, including ENABLE signals

Reaction wheels and magnetorquers are powered from separate power input (5 Volts).

3.9 Other Auxiliary Interfaces

- Second CAN interface
- UART interface
- ADC inputs
- GPIO / PWM signals
- Deployer outputs

4 Electrical Interface Description

3C2 flight computer board can be powered through PC/104 stack H1/H2 headers. The flight computer itself only requires single 3.3 Volt power supply. 5 Volt power rail is routed through 3C2 board to power reaction wheels and magnetorquers. Software development and debugging are performed through SWD interface using ST-Link/v2 or any other programming tool that supports SWD. SWD pins are accessible via 6-pin PicoBlade™ header (see Figure 2 and Figure 3).

4.1 PC/104 Stack Connector Pin Descriptions

SatBus 3C2 uses Type A (Samtec P/N SSQ-126-01-G-D) 2 row gold-plated Samtec stacking connectors. The default pin configuration is shown in Table 1 and Table 2.

Table 1. H1 (PC/104) Header Pin Description

Header Pin	Name	Description	Present in Default Configuration
1	CANL	CAN Low Line	Yes
3	CANH	CAN High Line	Yes
2	PPS	GPS Pulse Per Second Signal Output	Yes
5	GPIO_PA10	PA10 GPIO Signal	No, optional
7	GPIO_PH6	PH6 GPIO Signal	No, optional
8	GPIO_PH9	PH9 GPIO Signal	No, optional
9	GPIO_PH10	PH10 GPIO Signal	No, optional
10	GPIO_PD13	PH13 GPIO Signal	No, optional
13	ADC_1_IN4	PC4 / ADC1_IN4	No, optional
14	ADC_1_IN5	PB1 / ADC1_IN5	No, optional
15	ADC_1_IN8	PC5 / ADC1_IN8	No, optional
16	ADC_1_IN9	PB0 / ADC1_IN9	No, optional
41	I2C_SDA	I2C Serial Bus Data	No, optional
43	I2C_SCL	I2C Serial Bus Data	No, optional
47	5V_EPS_Input	5.0 Volt Power Input for Reaction Wheels and Magnetorquer	Yes
48	3V3_EPS_Input	3.3 Volts Power Input (Main Flight Computer Power)	Yes
50	3V3_EPS_Input2	UHF Subsystem 3.3 V Power[1]	No, optional

Table 2. H2 (PC/104) Header Pin Description

Header Pin	Name	Description	Present in Default Configuration
13	5V_EPS_Input	5.0 Volts Power Input for Reaction Wheels and Magnetorquer[1]	No, optional
18	3V3_EPS_Input	3.3 Volts Power Input (Main Flight Computer Power)[1]	No, optional
27	3V3_OA_Input	3.3 Volts Supply for UHF Subsystem	Yes
28	3V3_OA_Input	3.3 Volts Supply for UHF Subsystem	Yes
29	GND	Ground	Yes
30	GND	Ground	Yes
32	GND	Ground	Yes

[1] Option 2 in the option sheet.

4.2 Connector Layout

The board interfaces with external devices via PicoBlade™ wire to board connectors. Location of each connector and its corresponding pinout is show in Figure 2, Figure 3 and
Tables 3 - 30.

Table 3. SWD – SWD Programming Interface

Pin #	Description	Direction
1	SWO	Output
2	NRST	Input
3	SWDIO	I/O
4	GND	Ground
5	SWCLK	Input
6	NC	-

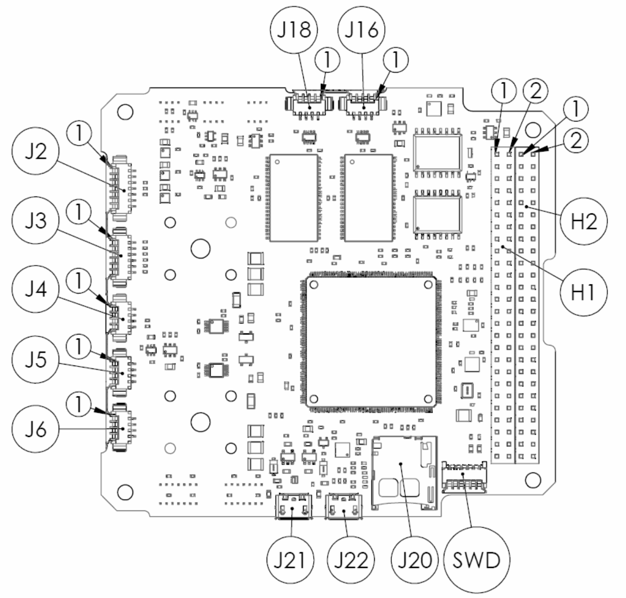

Figure 2. SatBus 3C2 Connectors – Top Side*

4.3 ADCS Sensor Connectors

Table 4. J2 – SPI4 (Sun Sensors)

Pin #	Description	Direction
1	GND	Ground
2	GND	Ground
3	MOSI	Output
4	MISO	Input
5	SCK	Output
6	+3.3 V SunSensor	Power
7	+3.3 V SunSensor	Power

Table 5. J3 – Chip Select Outputs (Sun Sensors)

Pin #	Description	Direction
1	Sun6_CS (PI15)	I/O
2	Sun5_CS (PI14)	I/O
3	Sun4_CS (PI13)	I/O
4	Sun3_CS (PI12)	I/O
5	Sun2_CS (PI11)	I/O
6	Sun1_CS (PI10)	I/O

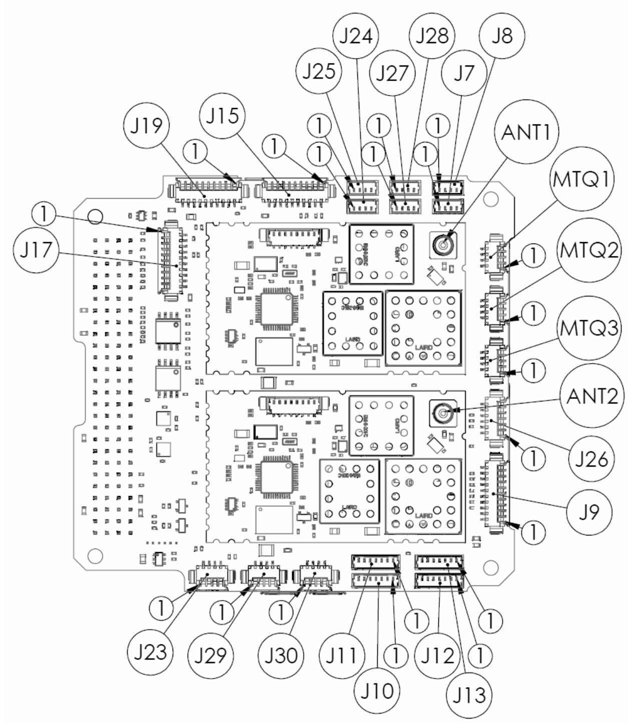

Figure 3. SatBus 3C2 Connectors – Bottom Side*

Table 6. J4 – I2C Sun Sensor Connector #1

Pin #	Description	Direction
1	+3.3 V SunSensor	Power
2	GND	Ground
3	I2C2_SDA	I/O
4	I2C2_SCL	Output

Table 7. J5– I2C Sun Sensor Connector #2

Pin #	Description	Direction
1	+3.3 V SunSensor	Power
2	GND	Ground
3	I2C2_SDA	I/O
4	I2C2_SCL	Output

* Drawing is not to scale.

Table 8. J6 – I2C Sun Sensor Connector #3

Pin #	Description	Direction
1	+3.3 V SunSensor	Power
2	GND	Ground
3	I2C2_SDA	I/O
4	I2C2_SCL	Output

Table 9. J7 – External I2C sensors Connector #1

Pin #	Description	Direction
1	+3.3 V Ext Sensors	Power
2	I2C3_SCL	Output
3	I2C3_SDA	I/O
4	GND	Ground

Table 10. J8 – External I2C sensors Connector #2

Pin #	Description	Direction
1	+3.3 V Ext Sensors	Power
2	I2C4_SCL	Output
3	I2C4_SDA	I/O
4	GND	Ground

Table 11. J9 – External SPI2 Sensor Interface

Pin #	Description	Direction
1	+3.3 V / *+5.0 V (Optional)	Power
2	+3.3 V / *+5.0 V (Optional)	Power
3	SPI2_Sensor_Enable (PJ4)	I/O
4	SPI2_SCK	Output
5	SPI2_MOSI	Output
6	SPI2_MISO	Input
7	SPI2_NSS	Output
8	Sun5_CS (PI14)	I/O
9	Sun6_CS (PI15)	I/O
10	GND	Ground

4.4 ADCS Actuator Connectors

Table 12. J10 – Reaction Wheel #1 (SPI) Connector

Pin #	Description	Direction
1	GND	Ground
2	RW1_CS (PJ12)	Output
3	SPI5_SCK	Output
4	SPI5_MISO	Input
5	SPI5_MOSI	Output
6	RW1_Enable (PJ0)	Output
7	+5 V RW	Power

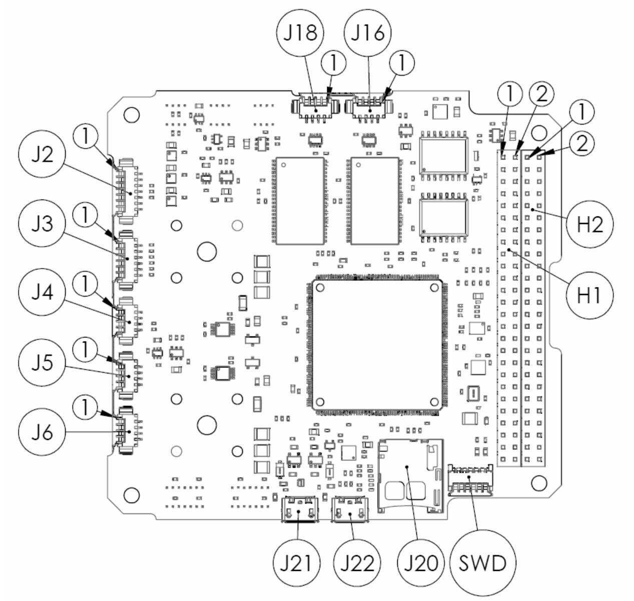

Figure 2. SatBus 3C2 Connectors – Top Side*

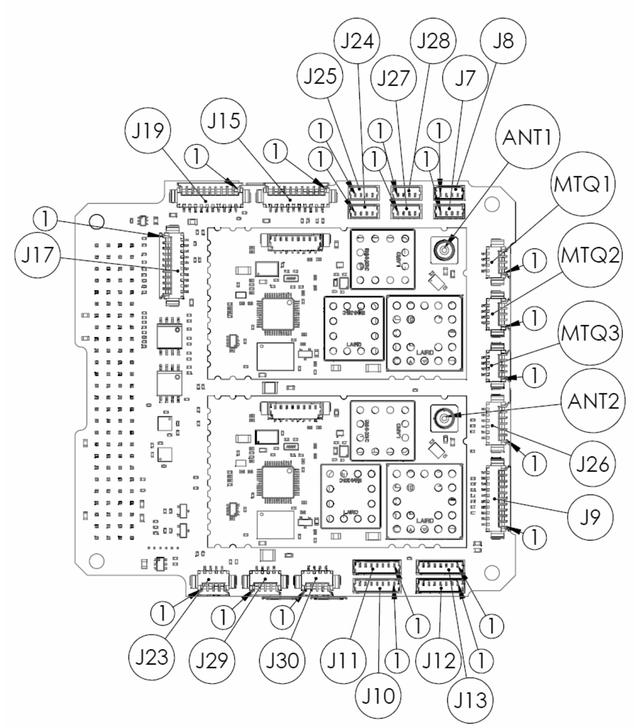

Figure 3. SatBus 3C2 Connectors – Bottom Side*

* Drawing is not to scale.

Table 13. J11 – Reaction Wheel #2 (SPI) Connector

Pin #	Description	Direction
1	GND	Ground
2	RW2_CS (PJ13)	Output
3	SPI5_SCK	Output
4	SPI5_MISO	Input
5	SPI5_MOSI	Output
6	RW2_Enable (PJ1)	Output
7	+5 V RW	Power

Table 14. J12 – Reaction Wheel #3 (SPI) Connector

Pin #	Description	Direction
1	GND	Ground
2	RW3_CS (PJ14)	Output
3	SPI5_SCK	Output
4	SPI5_MISO	Input
5	SPI5_MOSI	Output
6	RW3_Enable (PJ2)	Output
7	+5 V RW	Power

Table 15.J13 – Reaction Wheel #4 (SPI) Connector

Pin #	Description	Direction
1	GND	Ground
2	RW4_CS (PJ15)	Output
3	SPI5_SCK	Output
4	SPI5_MISO	Input
5	SPI5_MOSI	Output
6	RW4_Enable (PJ3)	Output
7	+5 V RW	Power

Table 16. MTQ1 – Magnetorquer #1

Pin #	Description	Direction
1	Magnetorquer1_A	Output
2	Magnetorquer1_A	Output
3	Magnetorquer1_B	Output
4	Magnetorquer1_B	Output

Table 17. MTQ2 – Magnetorquer #2

Pin #	Description	Direction
1	Magnetorquer2_A	Output
2	Magnetorquer2_A	Output
3	Magnetorquer2_B	Output
4	Magnetorquer2_B	Output

Table 18. MTQ3 – Magnetorquer #3

Pin #	Description	Direction
1	Magnetorquer3_A	Output
2	Magnetorquer3_A	Output
3	Magnetorquer3_B	Output
4	Magnetorquer3_B	Output

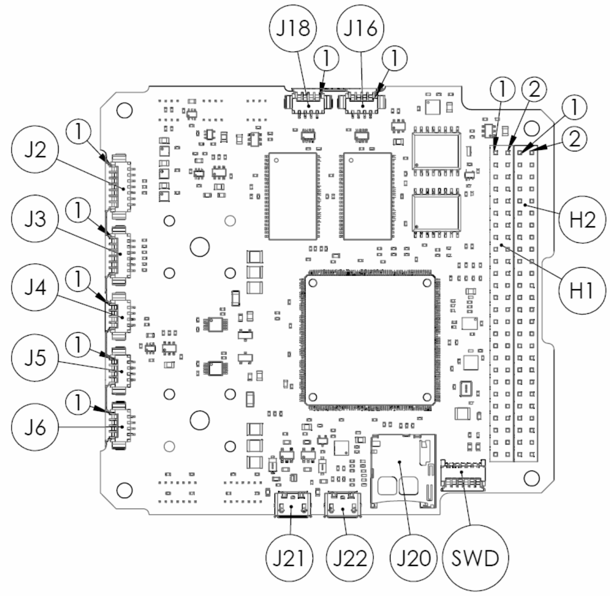

Figure 2. SatBus 3C2 Connectors – Top Side*

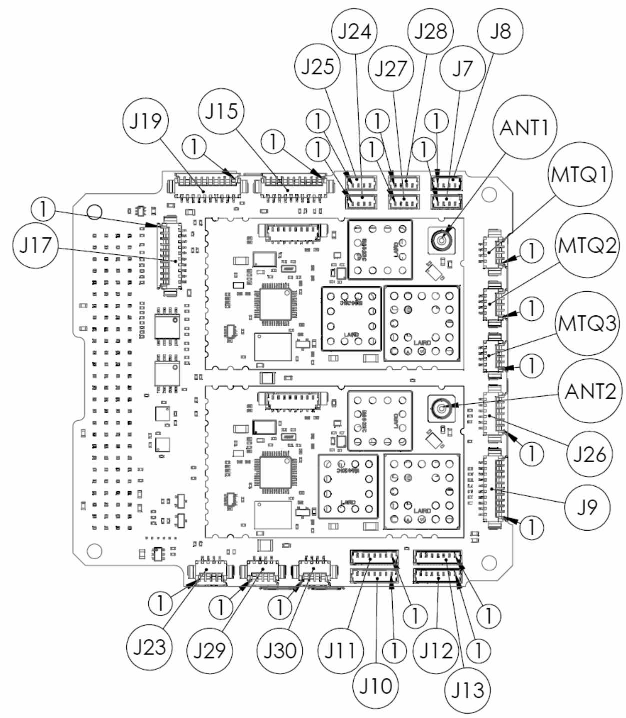

Figure 3. SatBus 3C2 Connectors – Bottom Side*

* Drawing is not to scale.

4.5 Other Subsystem / Auxiliary Connectors

Table 19. J15 – ECU (Propulsion Unit) Interface

Pin #	Description	Direction
1	GPS_PPS signal	Output
2	NC	-
3	UART5_TX	Output
4	UART5_RX	Input
5	CAN1_H	I/O
6	CAN1_H	I/O
7	CAN1_L	I/O
8	CAN1_L	I/O
9	GND	Ground
10	GND	Ground

Table 20. J17 – Payload Controller Interface

Pin #	Description	Direction
1	GPS_PPS signal	Output
2	NC	-
3	UART7_TX	Output
4	UART7_RX	Input
5	CAN1_H	I/O
6	CAN1_H	I/O
7	CAN1_L	I/O
8	CAN1_L	I/O
9	GND	Ground
10	GND	Ground

Table 21. J19 – GPS Unit Interface

Pin #	Description	Direction
1	GPS_TXD (USART1_RX)	Input
2	GPS_RXD (USART1_TX)	Output
3	GPS_PPS Signal Input	Input
4	GPS_PF (input, PG8)	Input
5	NC	-
6	NC	-
7	+3.3 V GPS	Power
8	+3.3 V GPS	Power
9	GND	Ground
10	GND	Ground

Table 22. J16 – CAN1 Connector

Pin #	Description	Direction
1	GND	Ground
2	CAN1_L	I/O
3	CAN1_H	I/O
4	+3.3 V CAN	Power

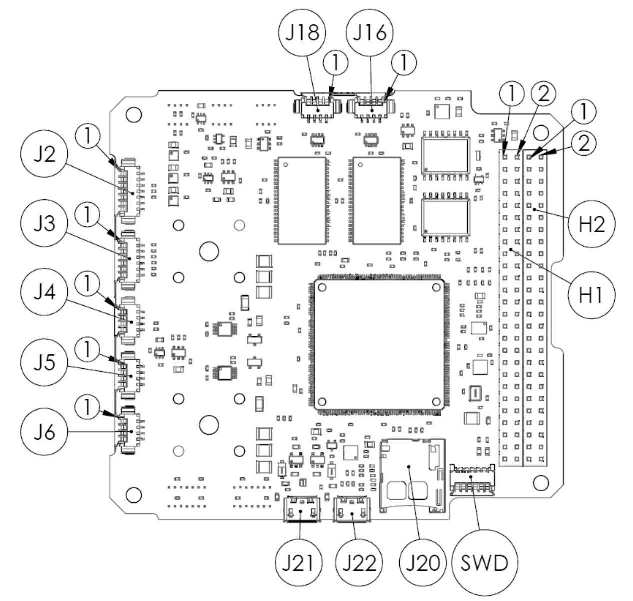

Figure 2. SatBus 3C2 Connectors – Top Side*

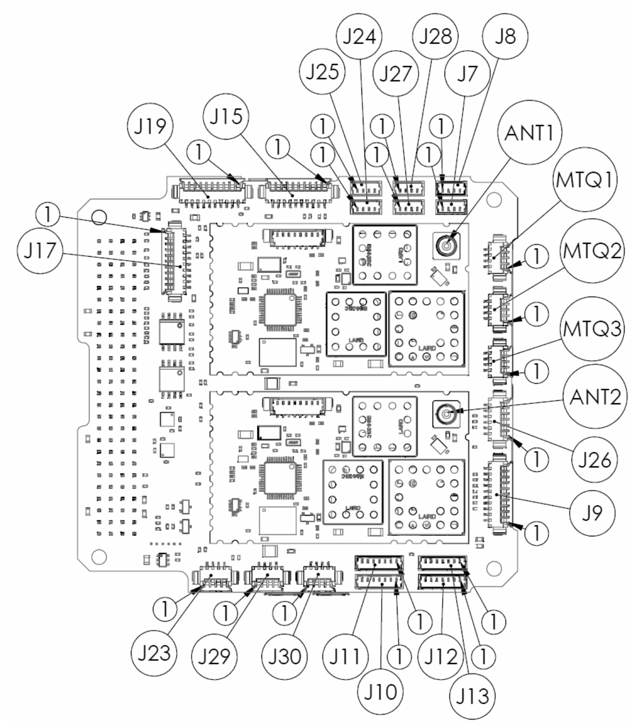

Figure 3. SatBus 3C2 Connectors – Bottom Side*

* Drawing is not to scale.

Table 23. J18 – CAN2 Connector

Pin #	Description	Direction
1	GND	Ground
2	CAN1_L	I/O
3	CAN1_H	I/O
4	+3.3 V CAN	Power

Table 24. J23 – UART Connector

Pin #	Description	Direction
1	+3.3 V UART8	Power
2	UART8 TX	Output
3	UART8 RX	Input
4	GND	Ground

4.6 ADC and GPIO Connectors

Table 25. J26 – GPIO / PWM Connector

Pin #	Description	Direction
1	GPIO_PH6	I/O
2	GPIO_PH9	I/O
3	GPIO_PH10	I/O
4	GPIO_PD13	I/O
5	GND	Ground
6	GND	Ground

Table 26. J24 – ADC Inputs Connector #1

Pin #	Description	Direction
1	ADC1_In2	Input
2	ADC1_In4	Input
3	+3.3 V ADC	Power
4	GND	Ground

Table 27. J25 – ADC Inputs Connector #2

Pin #	Description	Direction
1	ADC1_In5	Input
2	ADC1_In8	Input
3	+3.3 V ADC	Power
4	GND	Ground

Table 28. J27 – ADC Inputs Connector #3

Pin #	Description	Direction
1	ADC1_In9	Input
2	ADC1_In14	Input
3	+3.3 V ADC	Power
4	GND	Ground

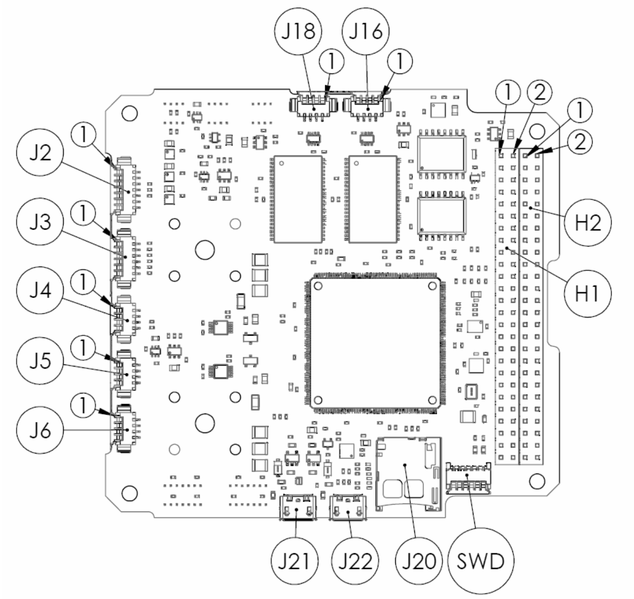

Figure 2. SatBus 3C2 Connectors – Top Side*

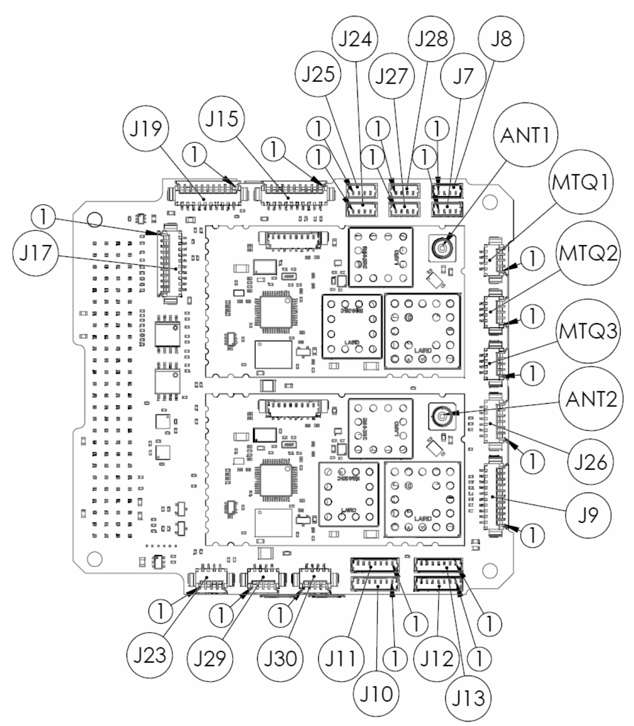

Figure 3. SatBus 3C2 Connectors – Bottom Side*

* Drawing is not to scale.

Table 29. J28 – ADC Inputs Connector #4

Pin #	Description	Direction
1	ADC1_In15	Input
2	ADC1_In16	Input
3	+3.3 V ADC	Power
4	GND	Ground

Table 30. J29 – Deployer Output #1

Pin #	Description	Direction
1	+5 V	Output
2	+5 V	Output
3	Deployer out1 (ctrl by PC8)	Output
4	Deployer out1 (ctrl by PC8)	Output

Table 31. J30 – Deployer Output #2

Pin #	Description	Direction
1	+5 V	Output
2	+5 V	Output
3	Deployer Out2 (ctrl by PC9)	Output
4	Deployer Out2 (ctrl by PC9)	Output

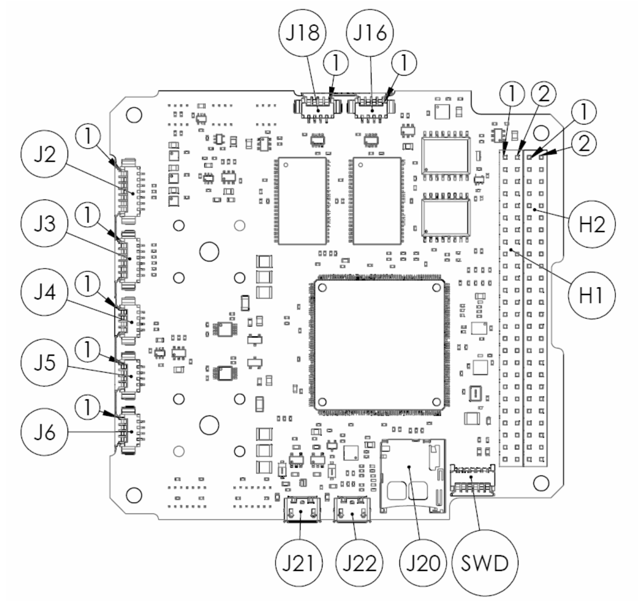

Figure 2. SatBus 3C2 Connectors – Top Side*

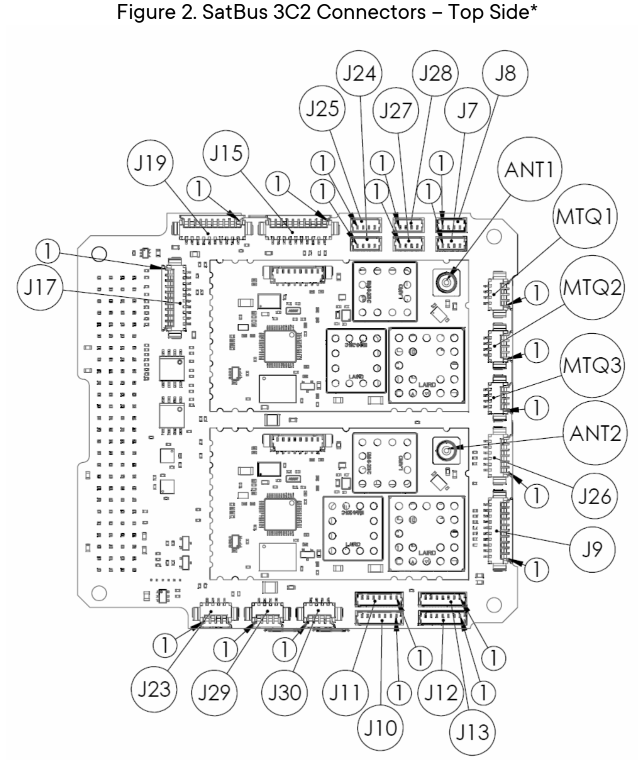

Figure 3. SatBus 3C2 Connectors – Bottom Side*

* Drawing is not to scale.

5 Electrical Interface Description

5.1 General Specifications

Table 32. General Specification, $T_A = 25$

Parameter	Conditions	Min	Typical	Max	Unit
VCC (3.3 V) Input Voltage		3.2	3.3	3.4	V
5.0 V Reaction Wheels / Magnetorquer Input Voltage		4.8	5.0	5.2	V
MCU Clock Frequency		-	200	400	MHz
Current Consumption	VCC = 3.3 V Clock 200 MHz, MCU Idle, No External Sensors	-	100	-	mA
NOR Flash Memory Max R/W Cycles		-	10^5	-	cycles
FRAM Memory Max R/W Cycles		-	10^{14}	-	cycles
Gyroscopes					
Integrated 3-axis Gyroscope Count		-	3	-	pcs
Scale Range		-	125	2000	°/s
Resolution		-	16	-	Bit
Cross-axis Sensitivity		-	±1	-	%
Magnetometer					
Field Range		-8	-	+8	Gauss
Resolution		-	0.25	-	mGauss
Linearity Error		-	0.2	-	%FS
CAN1, CAN2					
Differential Output Voltage (Dominant)	R_L = 60 Ω	1.6	-	3.0	V
Differential Output Voltage (Recessive)	R_L = Open (No Load)	-0.05	-	0.1	V
Bit-rate		-	125	1000	kbit/s
I2C2, I2C3, I2C4					
Voltage		0	-	3.3	V
Pull-up Resistors		-	2.2	-	kΩ
Frequency		-	100	400	kHz
SPI2, SPI5					
Voltage		0	-	3.3	V
Frequency		-	187	-	kHz
Magnetorquer Drivers					
Output Voltage		4.6	-	-	V
Output Current	I = 1.2 A,	-	-	1.2	A
Duty Cycle Resolution	$V_{CC\ MTQ}$ = 5.0 V	-	10	-	bit
PWM Frequency		-	10	-	kHz
UHF Communication Subsystem[2]					
UHF Module Current Limit (On 3C2 Mother Board):					
COMM1 Module		2.67	3.33	4.0	A
COMM2 Module		2.67	3.33	4.0	A
Heat Dissipation (Heatsink Requirement):					
One of COMM Modules at Full TX Power, 100% Duty Cycle		-	3.2	5	W
ADC Inputs					
RC Filter Cut-off Frequency		-	16	-	kHz
Input Impedance		10	-	-	kΩ
Deployer					
Deployer Output (Sink) Current		-	-	2.5	A

[2] Please Refer to SAT2RF1-1D Datasheet for All the UHF Subsystem Specifications.

Parameter	Conditions	Min	Typical	Max	Unit
Sensor / Subsystem Load Switches					
Magnetorquers Current Limit (Total Current) [3]		1.2	1.28	1.375	A
Sun Sensors Load Switch, Current Limit [3]		0.11	-	0.151	A
External I2C Sensors Load Switch, Current Limit [3]		0.1	-	0.2	A
GPS Load Switch, Current Limit [3]		0.234	0.25	0.303	A
CAN Connector (J6/J8) 3.3 V Current Limit		0.234	0.25	0.303	A
ADC Connectors (J24-J28) 3.3 V Current Limit		0.105	-	0.144	A
UART Connector (J23) 3.3 V Current Limit		0.105	-	0.144	A
Environmental					
Flight Computer Operating Temperature		-40	-	+85	°C
Flight Computer Including UHF Operating Temperature		-40	-	+50	°C
Storage Temperature		-40	-	+85	°C
Radiation Tolerance		-	20	-	kRad
Shock (2 ms Half-Sine Pulse, According to NASA GEVS 7000 Standard)		-	80	-	G
Vibration (According to NASA GEVS 7000 Standard)		-	14	-	Grms

5.2 Absolute Maximum and Minimum Ratings

Table 33. Absolute Maximum and Minimum Ratings

Symbol	Description	Min	Max	Unit
VCC_3V3	3C2 Board Supply Voltage (Non-operating)	-0.3	3.6	V
VCC_V	Magnetorquer Driver and RW Supply Voltage	-0.3	5.5	V
V_{IO}	Voltage on SPI/I2C/UART/GPIO Pins	-0.3	3.6	V

6 Software Description

6.1 Command Line Interface (CLI)

Integrated Command Line Interface (CLI) allows fast diagnostics out-of-the box, configuration and telemetry readout using a human-friendly text-command interface. It is available via J22 USB connector and VCP (Virtual COM Port) FTDI drivers.

6.2 CubeSat Space Protocol

NanoAvionics provides software support for CubeSat Space Protocol (CSP) based communication between different subsystems and 3C2. CSP can be used to ease communications between distributed embedded systems in small networks. The protocol is based on a 32-bit header containing both transport and network-layer information. CSP support is included in extended software package. For more information, please refer to CSP project website:
https://github.com/GomSpace/libcsp

6.3 Software Checkout and Upload On-orbit

The software for 3C2 Flight computer could be uploaded whilst on-orbit using NanoAvionics proprietary protocol that ensures data integrity and verification.

[3] Default option, this setting may be customized.

7 Layout

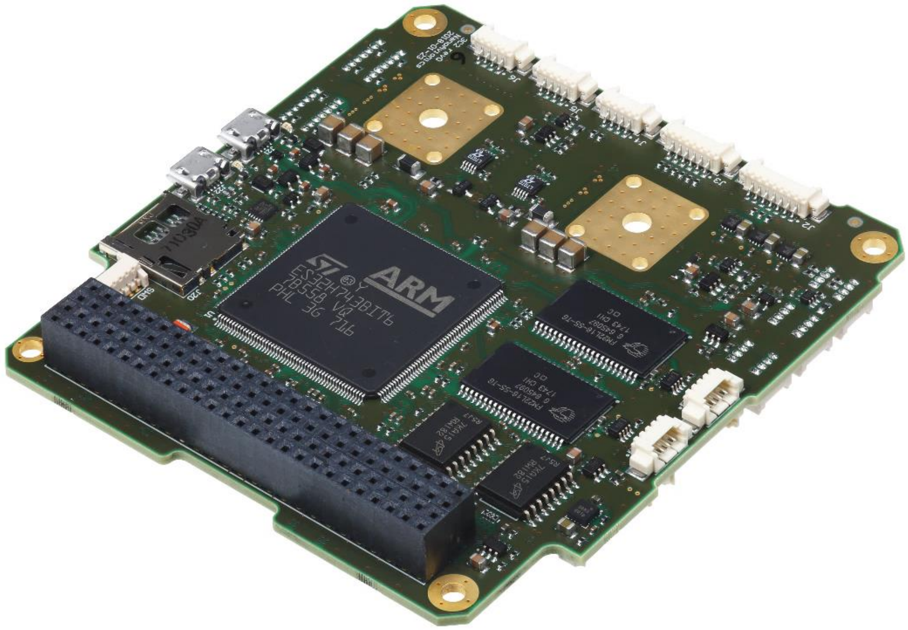

Figure 4. SatBus 3C2 General View – Upper

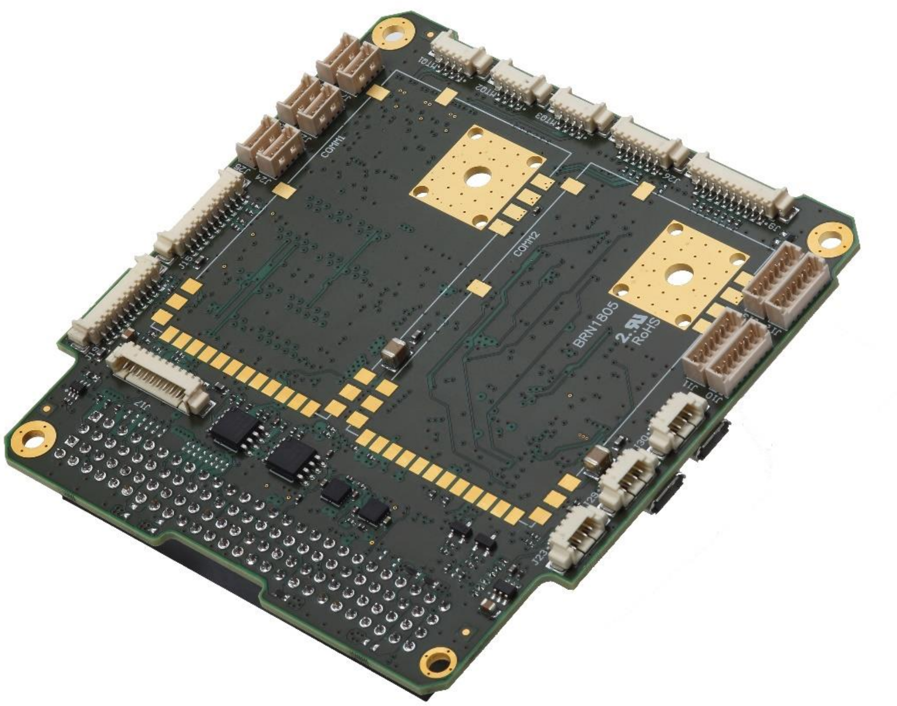

Figure 5. SatBus 3C2 General View - Lower

8 Mechanical Overview

8.1 Physical Dimensions

SatBus 3C2 mechanical design is compliant with PC/104 specifications. Dimensions of the PCB, including two redundant SAT2RF1-1D UHF modules but no heatsink, are shown in **Error! Reference source not found.** and are in mm.

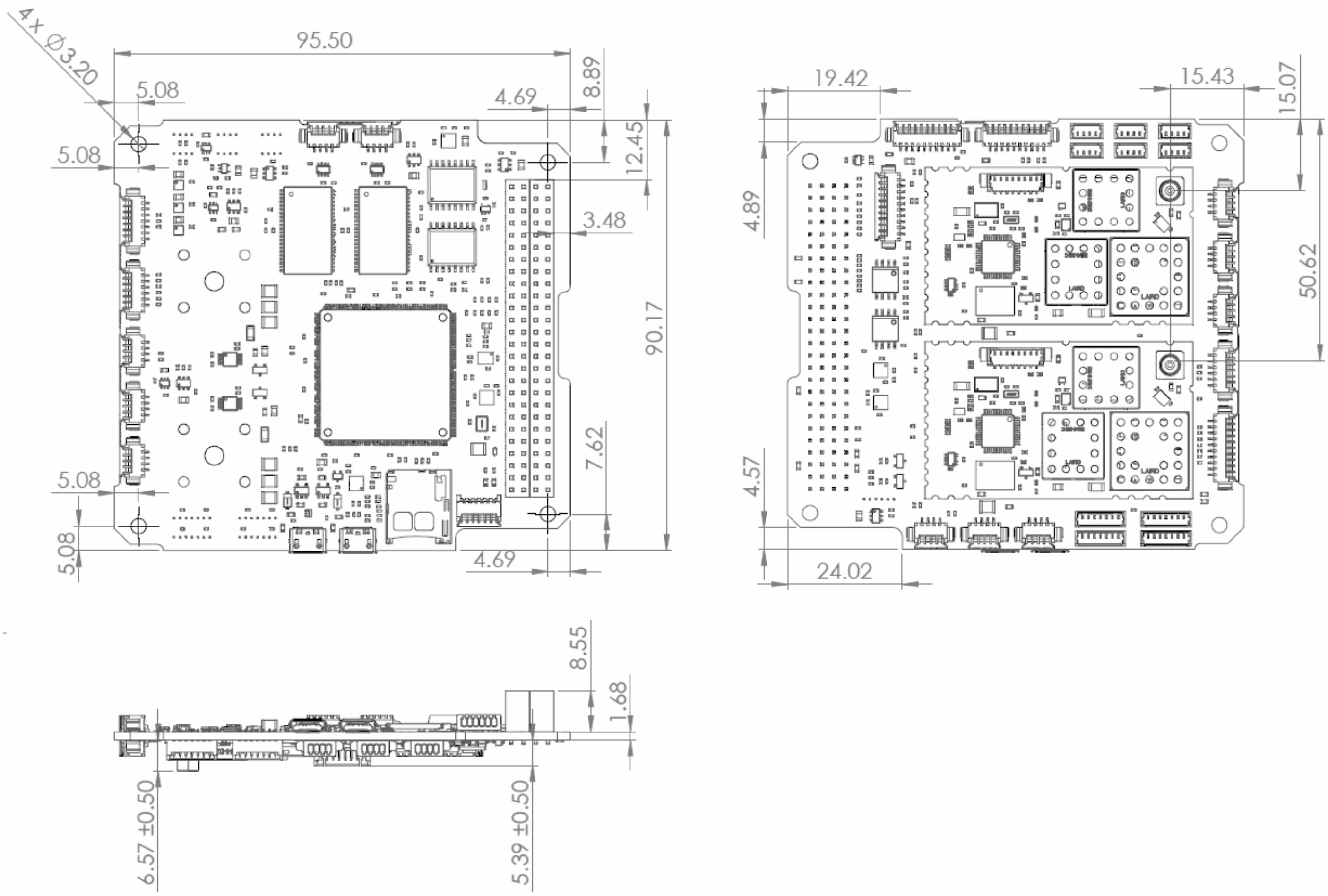

Figure 6. PCB Dimensions [4]

8.2 Mechanical Specifications

Table 34 Mechanical Specification

Parameter	Value
Mass, 3C2, Including Two UHF Modules	136 g (Typical)
Mass, 3C2, without UHF modules, without conformal coating	62 g (Typical)
PCB Material	FR-4 (E-glass/Epoxy)
Assembly Level	IPC-A-610 Class 2

[4] Drawing is not to scale.

9 Handling and Storage

NanoAvionics EPS requires specific guidelines to be observed for handling, transportation and storage. Failure to follow these guidelines may result in damage to the units or degradation in performance.

9.1 Protection for Electrostatic-Sensitive Devices (ESD)

It is essential to handle the device at static-safe workstations. ESD gloves and grounded antistatic wrist-strap as well as antistatic table surface will prevent damage from electrostatic discharge. Any accumulated charge on the body of the human operator should be discharged first before opening the protective container with ESD devices inside. The use of an antistatic smock for each worker is highly recommended.

9.2 General Handling

Gloves (ESD compliant) should be worn when handling all flight hardware.
The Flight Computer is robust and designed to withstand flight conditions. However, care must be taken when handling the device. Do not drop the device.

9.3 Shipping and Storage

The devices are shipped in anti-static packaging, enclosed in a Peli case. This case should be used for storage. All hardware should be stored in anti-static containers at temperatures between 20°C and 40°C and in a humidity-controlled environment of 40-60%rh.

10 Disclaimer

The information in this document is subject to change without notice and should not be construed as a commitment by NanoAvionics, LLC. NanoAvionics assumes no responsibility for any errors that may appear in this document.