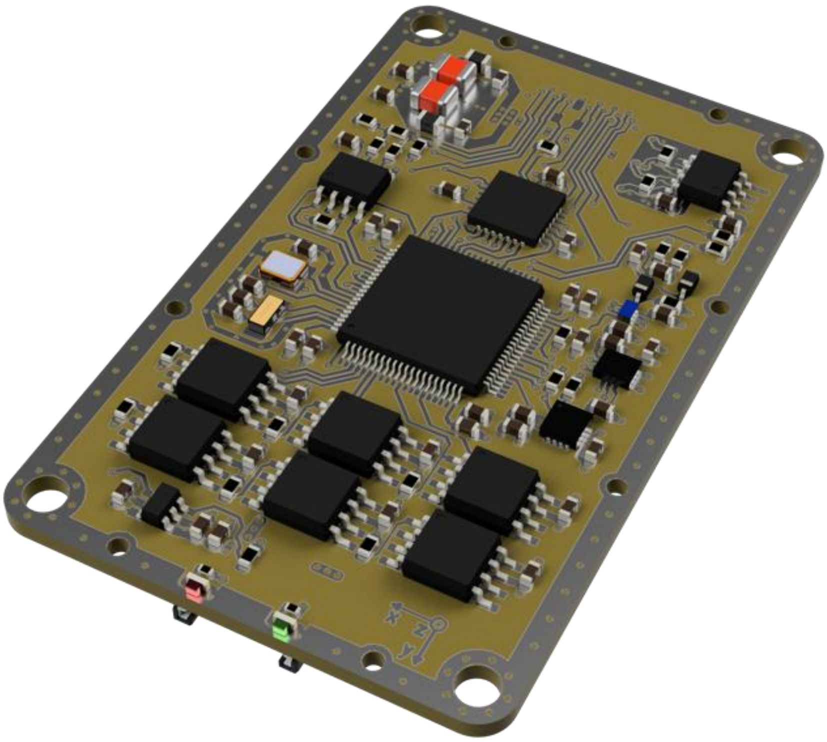

EDDIE OBC

DATASHEET

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GLOSSARY

CAN	Controller Area Network
CDHS	Command Data Handling System
CSP	Cubesat Space Protocol
FRAM	Ferroelectric RAM
I^2C	Inter Integrated Circuit
IC	Integrated Circuit
KISS	"Keep It Simple, Stupid" (popular radio amateur protocol)
MCU	Micro Controller Unit
OBC	On-Board Computer
RS485	Differential bus standard
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver Transmitter

1 PRODUCT OVERVIEW

Eddie is an on-board computer module suitable for integration in small satellite applications such as satellite CDHS or payload computer. The module is based on MSP430FR5994 mixed-signal microcontroller by Texas Instruments.

Flight heritage on 10+ missions (e.g. LASARsat, CroCube, GRBBeta and external customers).

2 TECHNICAL SPECIFICATION

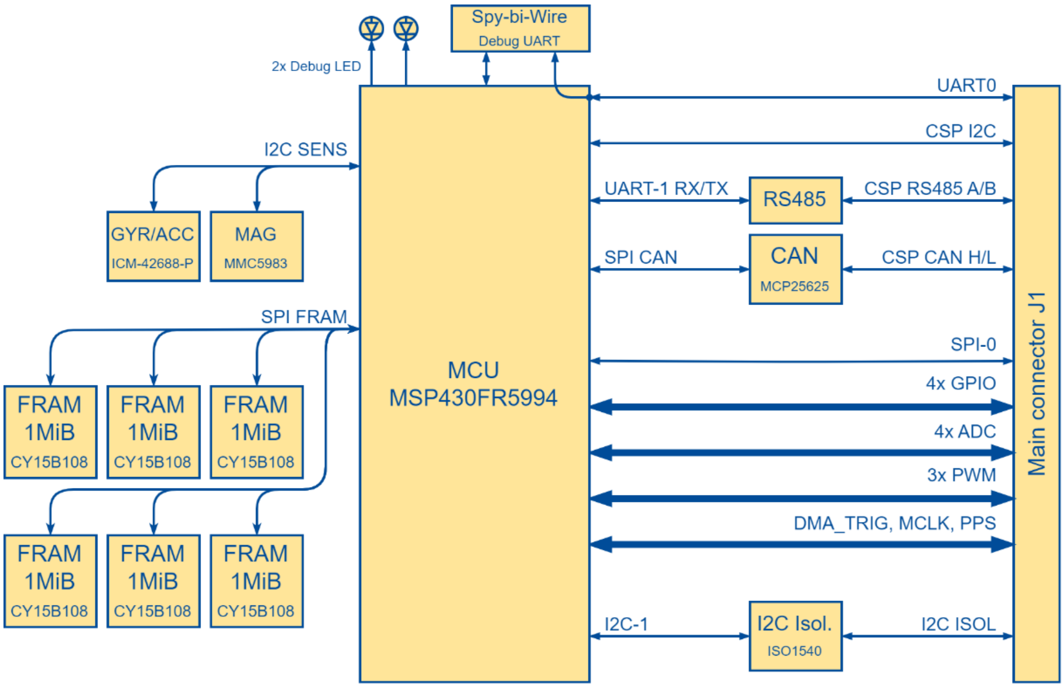

Figure 2-1: Eddie OBC v4a block diagram

Table 2-1: Technical specification

Parameter	Value	Unit
Operating Temperature	-40 to +85	°C
Dimensions	67 x 42 x 7.5	mm
Mass	25	g
Power Supply	3.3 5 (for CAN)	V
Power Consumption - average	60	mW
Power Consumption - peak	100	mW

Power consumption is directly proportional to implemented software. Presented specification represent typical usage in Spacemanic applications on CSP based satellite buses.

Table 2-2: Key OBC parameters

Parameter	Value	Unit
MCU	MSP430FR5996	
HF Crystal	16	MHz
LF Crystal	32.768	kHz
Data storage external FRAM	6 x 1	MiB
Operating system	FreeRTOS (alt. Custom)	
On-board magnetometer	MMC5983	
On-board gyroscope & accelerometer	ICM-42688-P	

Table 2-3: Overview of interfaces

Interface	Description
UART-0	Typically implements plain text CLI. Available on both debug and main connectors.
CSP I^2C	CSP over I^2C bus. Speed up to 400 kHz
CSP RS485	CSP over RS485 KISS. Speed up to 38400 Baud rate.
CSP CAN	CSP over CAN. Speed up to 1 Mbit/s
I^2C-SENS	Internal only. Connects to on-board sensors. Speed up to 400kHz
SPI-MEM	Internal only. Connects to on-board FRAM memories. Speed up to 16 MHz.
I^2C-ISOL	Isolated plain I^2C bus, typically used for external sensors. Speed up to 400 kHz.
SPI-0	External SPI for sensor interfacing. Speed up to 16 MHz.
ADC	5 x 12bit with 3.3 V range.
PWM	3 x 3.3 V range.
GPIO	Up to 18 x 3.3 V range. Shares pins with SPI-0, ADC, PWM.

3 INTERFACES

3.1 ELECTRICAL

Table 3-1: Electrical characteristics

Parameter	Min.	Typ.	Max.	Unit
Power Input	-0.2	3.3	+3.6	V
Current draw (3.3 V)	-	10	40	mA
Current draw (5 V)	4	5	70	mA
GPIO Level (including comm. Buses)	-0.2	3.3	+3.6	V
GPIO Pin current	-2	-	+2	mA

Note: Since most communication buses and GPIO are connected directly to the MCU, for more details on ratings refer to MSP430FR5994 documentation and main connector J1 documentation.

3.1.1 PROGRAMMING AND DEBUG INTERFACE

Programming is done by a Spy-Bi-Wire interface on the front facing debug connector. Also present is Debug UART (UART-0).

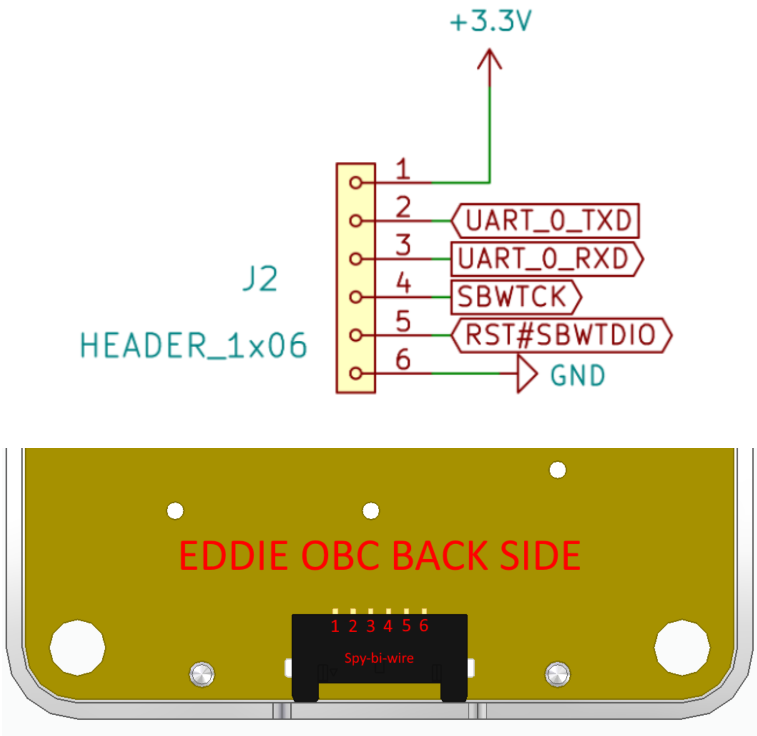

Figure 3-1: Programming connector

Table 3-2: Main connector reference

Connector	Type
Programming (on module)	Molex PicoLock 503763-0691
Programming (on motherboard)	Molex PicoLock 503764-0601 (crimp housing)

It is **NOT** recommended to use the programming connector as the power supply of the OBC module.

3.1.2 MAIN CONNECTOR

The main interface of the module with its motherboard is realized using a board-to-board connector. This connector includes all interfaces of the module apart from programming.

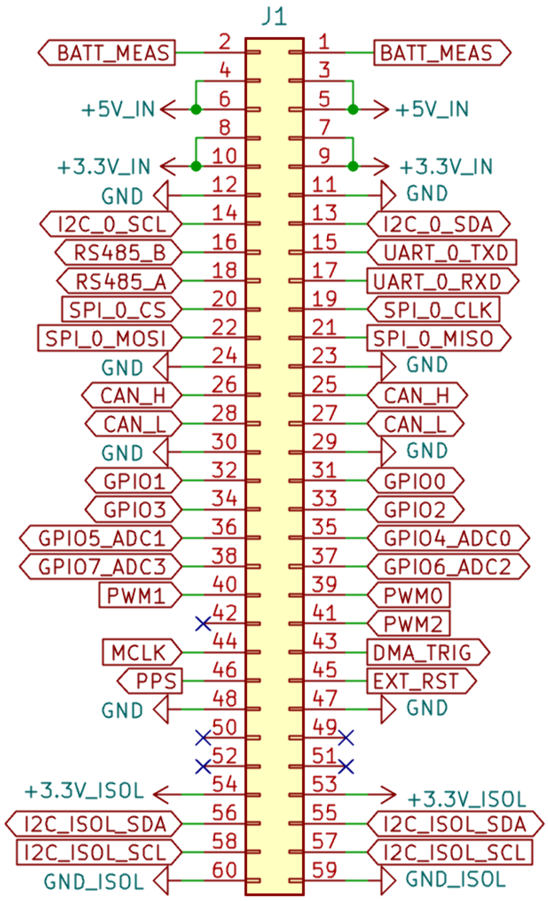

Figure 3-2: Main connector (J1)

Table 3-3: Main connector reference

Connector	Type
Main J1 (on module)	Molex SlimStack 55650-0688
Main J1 (on motherboard)	Molex SlimStack 54363-0689

When designing a motherboard for the Eddie OBC module, **ALWAYS** connect all power and ground pins to suitable power supply.

Table 3-4: Pin description of the Eddie OBC main connector (J1)

PN	Schematic name	Alt. functions	Pin attributes *	Notes
1	+BATT	ANALOG IN A17	P7.5 A17	Connected as additional ADC input.
2	+BATT	ANALOG IN A17	P7.5 A17	See PN 1.
3	+5V_IN	+5V_IN	-	CAN driver power supply. If CAN driver is not to be used, this pin may be left not connected.
4	+5V_IN	+5V_IN	-	See PN 3.
5	+5V_IN	+5V_IN	-	See PN 3.
6	+5V_IN	+5V_IN	-	See PN 3.
7	+3.3V_IN	+3.3V_IN	-	Board power supply.
8	+3.3V_IN	+3.3V_IN	-	See PN 7.
9	+3.3V_IN	+3.3V_IN	-	See PN 7.
10	+3.3V_IN	+3.3V_IN	-	See PN 7.
11	GND	GND	-	
12	GND	GND	-	
13	I2C_0_SDA	CSP I2C SDA	P6.4 UCB3MOSI UCB3SDA	Preconfigured for CSP operation. Possible use with non-CSP devices at the risk of losing connectivity when non-CSP device malfunctions.
14	I2C_0_SCL	CSP I2C SCL	P6.5 UCB3MISO UCB3SCL	Preconfigured for CSP operation. Possible use with non-CSP devices at the risk of losing connectivity when non-CSP device malfunctions.
15	UART_0_TXD	GPIO Debug UARTa0 Tx SPIa0 MOSI	P2.0 TB0.6 UCA0TXD BSLTX UCA0MOSI TB0CLK ACLK	Shared with Debug/Programming connector.
16	RS485_B	CSP RS485 B	-	Reserved for CSP operation. Internally used UART on P5.4 and P5.5.
17	UART_0_RXD	GPIO Debug UARTa0 Rx SPIa0 MISO	P2.1 TB0.0 UCA0RXD BSLRX UCA0MISO	Shared with Debug/Programming connector.
18	RS485_A	CSP RS485 A	-	Reserved for CSP operation. Internally used UART on P5.4 and P5.5.
19	SPI_0_CLK	GPIO SPIa1 CLK PWM/capture ANALOG IN A7 comparator in C11	P2.4 TA1.0 UCA1CLK A7 C11	
20	SPI_0_CS	GPIO SPIa1 STE PWM/capture ANALOG IN A6 comparator in C10	P2.3 TA0.0 UCA1STE A6 C10	

PN	Schematic name	Alt. functions	Pin attributes *	Notes
21	SPI_0_MISO	GPIO SPIa1 MISO UARTa1 RX PWM/capture	P2.6 TB0.1 UCA1RXD UCA1MISO	
22	SPI_0_MOSI	GPIO SPIa1 MOSI UARTa1 TX PWM/capture	P2.5 TB0.0 UCA1TXD UCA1MOSI	
23	GND	-	-	
24	GND	-	-	
25	CAN_H	-	-	CAN Interfaced over SPI CAN IC.
26	CAN_H	-	-	CAN Interfaced over SPI CAN IC.
27	CAN_L	-	-	CAN Interfaced over SPI CAN IC.
28	CAN_L	-	-	CAN Interfaced over SPI CAN IC.
29	GND	-	-	
30	GND	-	-	
31	GPIO0	GPIO	P4.7	
32	GPIO1	GPIO	P4.6	
33	GPIO2	GPIO	P4.5	
34	GPIO3	GPIO Timer/PWM/Captu re	P4.4 TB0.5	
35	GPIO4_ADC0	GPIO ANALOG IN A11	P4.3 A11	
36	GPIO5_ADC1	GPIO ANALOG IN A10	P4.2 A10	
37	GPIO6_ADC2	GPIO ANALOG IN A9	P4.1 A9	
38	GPIO7_ADC3	GPIO ANALOG IN A8	P4.0 A8	
39	PWM0	GPIO PWM SPIb0 STE ANALOG A3 COMPARATOR C3	P1.3 TA1.2 UCB0STE A3 C3	
40	PWM1	GPIO PWM SPIb0 STE ANALOG A4 COMPARATOR C4	P1.4 TB0.1 UCA0STE A4 C4	
41	PWM2	GPIO PWM SPIa0 CLK ANALOG A5 COMPARATOR C5	P1.5 TB0.2 UCA0CLK A5 C5	
42	-	-	-	
43	DMA_TRIG	GPIO PWM RTC Out ANALOG A0 COMPARATOR C0 ANALOG Vref-	P1.0 TA0.1 DMAE0 RTCCLK A0 C0 VREF- VeREF-	

PN	Schematic name	Alt. functions	Pin attributes *	Notes
44	MCLK	GPIO PWM/capture 16MHz out	P5.7 UCA2STE TA4.1 MCLK	
45	EXT_RST	-	-	Reserved for future use. Do not connect.
46	PPS	GPIO PWM/capture timer clock in ANALOG A1 comparator C1 Vref+	P1.1 TA0.2 TA1CLK COUT A1 C1 VREF+ VeREF+	Reserved for use as 1 pulse per second input for time synchronization, when using with Spacemanic Celeste GNSS module.
47	GND	-	-	
48	GND	-	-	
49	-	-	-	
50	-	-	-	
51	-	-	-	
52	-	-	-	
53	+3.3V_ISOL	-	-	Needs to be powered externally for the I^2C isolator to work!
54	+3.3V_ISOL	-	-	Needs to be powered externally for the I^2C isolator to work!
55	I2C_ISOL_SDA	-	P1.6 TB0.3 UCB0SIMO UCB0SDA TA0.0	Reserved for non-CSP use, can be reconfigured at the cost of losing secondary I^2C bus (GPIO open drain to GND, pulled high, input/output)
56	I2C_ISOL_SDA	-	P1.6 TB0.3 UCB0SIMO UCB0SDA TA0.0	Reserved for non-CSP use, can be reconfigured at the cost of losing secondary I^2C bus (GPIO open drain to GND, pulled high, input/output)
57	I2C_ISOL_SCL	-	P1.7 TB0.4 UCB0SOMI UCB0SCL TA1.0	Reserved for non-CSP use, can be reconfigured at the cost of losing secondary I^2C bus (GPIO open drain to GND, pulled high, input/output)
58	I2C_ISOL_SCL	-	P1.7 TB0.4 UCB0SOMI UCB0SCL TA1.0	Reserved for non-CSP use, can be reconfigured at the cost of losing secondary I^2C bus (GPIO open drain to GND, pulled high, input/output)
59	GND_ISOL	-	-	Needs to be grounded externally for the I^2C isolator to work!
60	GND_ISOL	-	-	Needs to be grounded externally for the I^2C isolator to work!

* (MCU datasheet https://www.ti.com/lit/ds/symlink/msp430fr5994.pdf)

Color coding:

(light blue) Reserved for payload, free to use and reconfigure.

(yellow) Reserved for specified use, can be reconfigured if needed.

(red) Not configurable, specified by hardware.

3.1.3 DEBUG UART (UART-0)

Table 3-5: Debug UART (UART-0) pin reference

Signal	J1 Pin	Debug pin	MCU Pin
TX	15	2	P6.4
RX	17	3	P6.5

The Debug UART is also connected to the Debug/Programming connector. The connection is directly to MCU pins.

3.1.4 CSP I²C (I2C-0)

Table 3-6: CSP I²C (I2C-0) pin reference

Signal	J1 Pin	MCU Pin
SDA	13	P6.4
SCL	14	P6.5

This I²C bus is directly connected to the controller and does not include any pull-up resistors. User is advised to use external 3.3 kΩ pull-up resistors to 3.3 V level.

If the module is to be turned OFF while still connected to an actively used I²C bus, an I²C separator is recommended (e.g. *NXP PCA9507* or *TI ISO1540)*.

3.1.5 CSP RS485 (UART-1)

Table 3-7: Debug UART (UART-0) pin reference

Signal	J1 Pin	MCU Pin
TX	-	P5.4
RX	-	P5.5
/RE	-	P6.7
DE	-	P2.7
A	18	-
B	16	-

The RS485 interface connects MCU UART and direction controlling GPIO to an RS485 differential bus driver. This circuit includes outside facing 10 Ω serial resistors and not populated termination and bias resistors. It is recommended to implement termination and bias on module's motherboard.

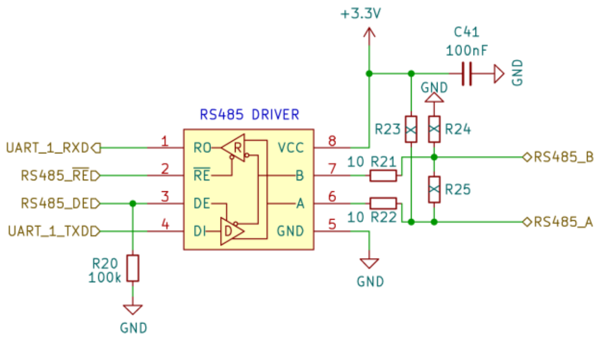

Figure 3-3: RS485 driver circuit

3.1.6 CSP CAN (SPI CAN)

Table 3-8: CSP CAN pin reference

Signal	J1 Pin	MCU Pin
H	55/56	-
L	57/58	-
SPI CAN Data Input (SI)	-	P5.0
SPI CAN Data Output (SO)	-	P5.1
SPI CAN Clock	-	P5.2
SPI CAN Chip Select	-	P5.3
SPI CAN /INT	-	P3.6
SPI CAN /Rx0BF	-	P3.7
SPI CAN /Rx1BF	-	P8.3
SPI CAN STBY	-	P8.2
SPI CAN RST	-	P3.4
SPI CAN CLK 16MHz	-	P5.6

The CAN bus interface is realized using an SPI CAN interface IC: MCP25625. The CAN interface needs to have module's **+5V_IN** line supplied to function.

There is no termination or serial resistors implemented on-board.

3.1.7 ISOLATED I²C (I2C-1)

Table 3-9: ISOL I²C (I2C-1) pin reference

Signal	J1 Pin	MCU Pin
SDA	55/56	P1.6
SCL	57/58	P1.7

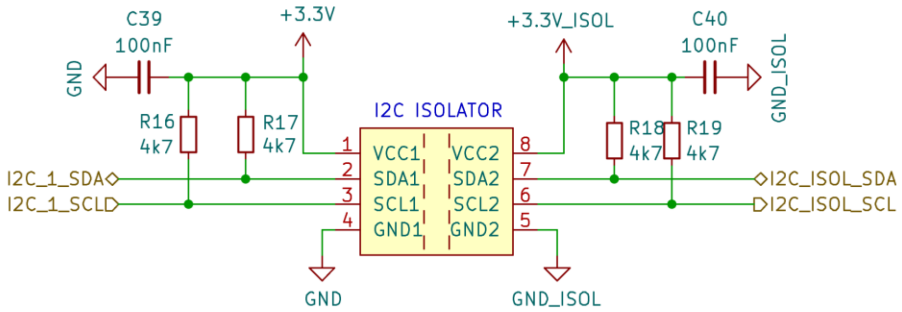

Figure 3-4: ISOL I²C (I2C-1) circuit

This I²C bus is connected to an isolator IC. For this interface to function an external power and ground needs to be connected to +3.3V_ISOL and GND_ISOL. It is recommended to use 3.3V power, but up to 5.5 V can be used. The outside facing I2C voltage level is directed by the externally connected power supply.

The outside facing side of the isolator already implements 4.7 kΩ pull-up resistors connected to the +3.3V_ISOL line.

3.1.1 SENSOR SPI-0

Table 3-10: GPIO, ADC, PWM pin reference

Signal	J1 Pin	MCU Pin
CLK	19	P2.4
CS	20	P2.3
MISO	21	P2.6
MOSI	22	P2.5

SPI interface on the main connector is available for any user application. Pins are connected directly from the MCU to the connector. Speed of the bus is up to 16 MHz.

Alternatively, all four pins may be used as GPIO.

3.1.2 GPIO, ADC, PWM

Table 3-11: GPIO, ADC, PWM pin reference

Signal	J1 Pin	MCU Pin
GPIO0	31	P4.7
GPIO1	32	P4.6
GPIO2	33	P4.5
GPIO3	34	P4.4
GPIO4 / ADC0	35	P4.3
GPIO5 / ADC1	36	P4.2
GPIO6 / ADC2	37	P4.1
GPIO7 / ADC3	38	P4.0
PWM0	39	P1.3
PWM1	40	P1.4
PWM2	41	P1.5
DMA TRIG	43	P1.0
MCLK	44	P5.7
PPS	46	P1.1
+BATT	1/2	P7.5

The OBC exposes a number of pins directly connected from the MCU for use as general purpose I/O, Analog measurement input, PWM output or special functions. Refer to MCU documentation for the exact usage via software.

Extra GPIO:

- **DMA_TRIG**: implements special functionality to be used as external DMA trigger.
- **MCLK**: implements special function to output MCU's internal clock.
- **PPS**: extra GPIO reserved for use as Pulse-Per-Second input if implemented in software.
- **+BATT**: extra ADC input meant for analog battery measurement. It does NOT implement any scaling or protection circuits. It is connected directly to the MCU.

3.1.3 SENS I²C AND INTERNAL SENSORS

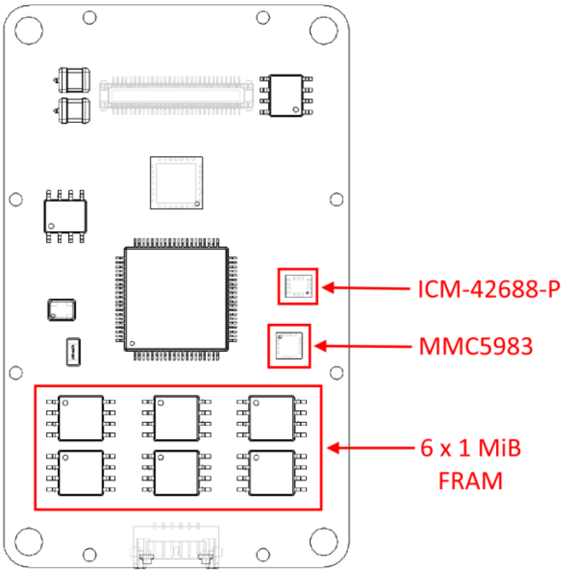

Figure 3-5: Internal sensor and FRAM memory placement

Table 3-12: SENS I²C pin reference

Signal	J1 Pin	MCU Pin
SDA	-	P7.0
SCL	-	P7.1
MAG SENS INT	-	P7.2
GYR SEN INT1	-	P7.3
GYR SENS INT2	-	P7.4

This I²C bus is connected internally to on-board magnetometer and gyroscope & accelerometer sensors including their respective interrupt signals. This bus is not accessible outside of the module.

MAGNETOMETER

The Eddie OBC module integrates a three-axis MEMS magnetometer (MMC5983). The sensor also includes temperature information. Refer to manufacturer documentation for details or the example software for basic usage.

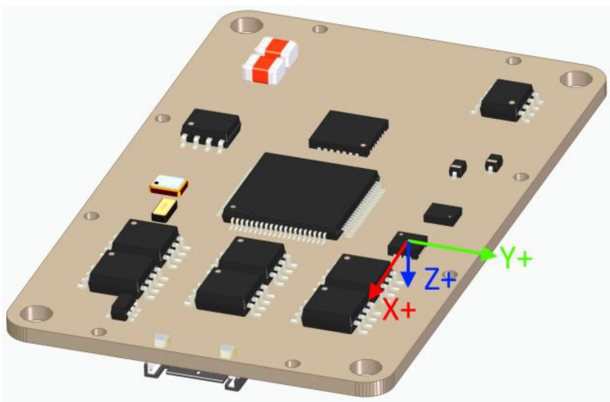

Figure 3-6: Magnetometer coordinate system (left-handed)

GYROSCOPE & ACCELEROMETER

The Eddie OBC module integrates a three-axis MEMS gyroscope & accelerometer sensor (ICM-42688-P). The sensor also includes temperature information. Refer to manufacturer documentation for details or the example software for basic usage.

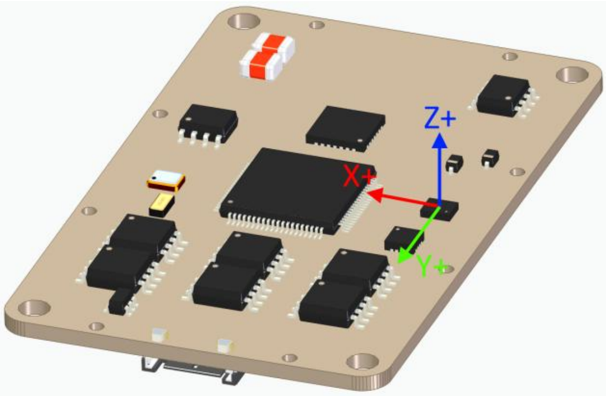

Figure 3-7: Gyroscope & accelerometer coordinate system

3.1.4 FRAM SPI

The module integrates 6 FRAM memory ICs (CY15B108QN), each with 1 MB data capacity. All are available for user implementation into mission specific software. Maximum SPI speed is 16 MHz of the MCU clock. Spacemanic example software includes an implementation where all ICs are used as one FatFs disk device.

Table 3-13: FRAM SPI pin reference

Signal	J1 Pin	MCU Pin
FRAM SPI MOSI	-	P6.0
FRAM SPI MISO	-	P6.1
FRAM SPI SCK	-	P6.2
FRAM 1 CS	-	P3.0
FRAM 2 CS	-	P3.2
FRAM 3 CS	-	P6.3
FRAM 4 CS	-	P3.1
FRAM 5 CS	-	P3.3
FRAM 6 CS	-	P8.0

3.2 SOFTWARE

The OBC is fully programable and reprogrammable by the user using the programming/debug connector via supported Texas Instruments tools such as MSP-FET or suitable Texas Instruments Launchpad.

Spacemanic offers an open-source software example project available at:

https://gitlab.com/spacemanic-public/ed-fw-example

This software is available as-is without any warranty. For extensive software support and development support contact Spacemanic directly.

3.3 MECHANICAL

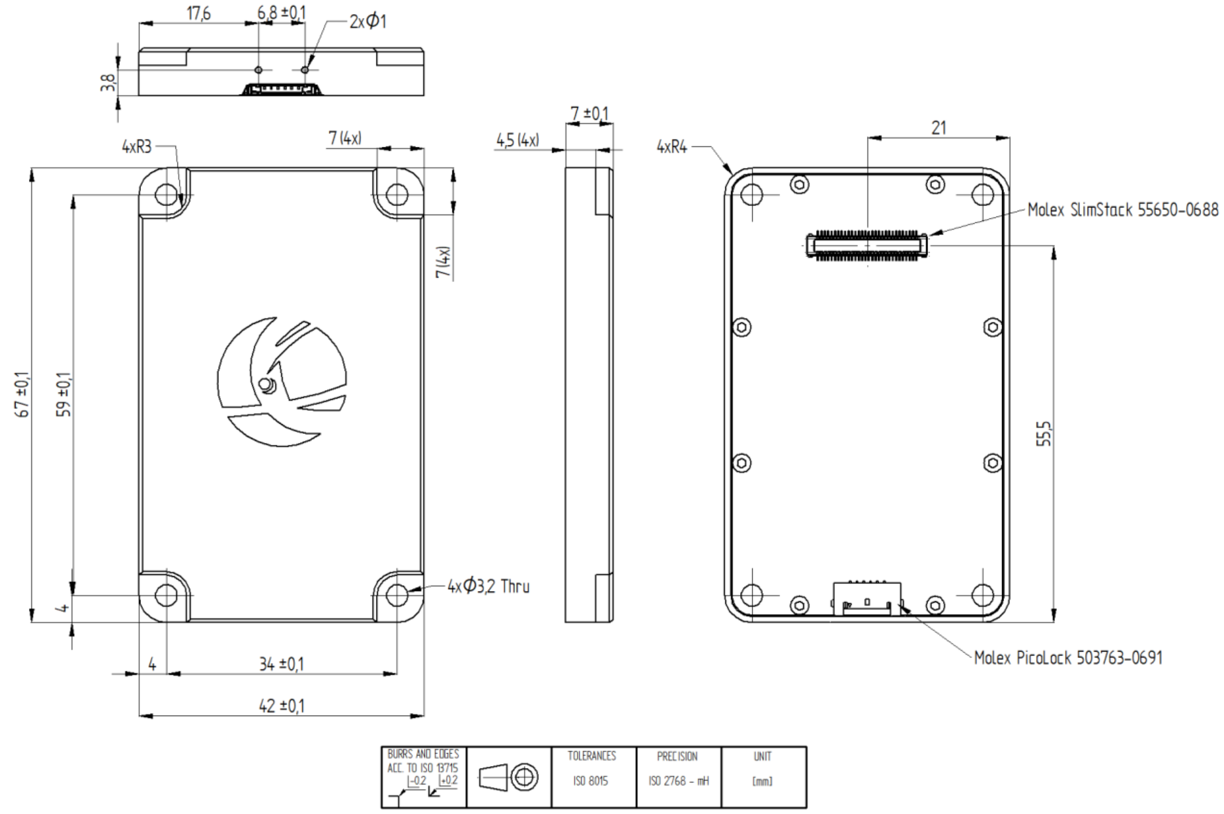

Figure 3-8: Mechanical interface of Eddie OBC module

It is recommended to mount the module using four ISO 14579 M3x6 socket head hexalobular Torx titanium grade 5 screws against 2.1 mm M3 spacers on the motherboard.

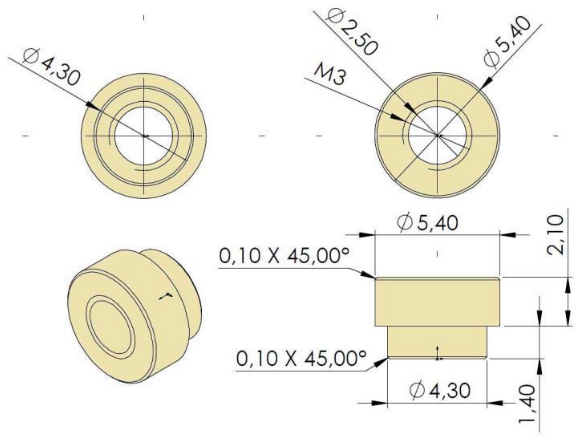

Figure 3-9: Recommended mounting spacer (brass)

4 DELIVERABLES

Table 4-1: Deliverables

Type	Item	Note
Mechanical Part	Aluminium cover	
Mechanical Part	USS module standoffs	
Interface	USS module V1b/V1c/V2b	
Wiring	Debug cable	(503764-0601) ~15cm terminated to female 2.54mm header
Support	Engineering support: 1 hour	

5 RELATED PRODUCTS

You may be also interested in:

- DeepThought OBC
- 1-16U CubeSat Platforms / Complete Mission

6 DISCLAIMER

Spacemanic shall not be liable for any damages, losses, delays, or other consequences arising from improper use, unauthorized modifications, or incompatibility of the product with other systems, even in cases where these products are deployed in demanding environments such as satellite or space applications. The product is designed for specific use according to the technical specifications outlined in the official documentation, and the company is not responsible for any issues arising from usage beyond this scope.

The company is also not liable for damages caused by external factors that cannot be predicted or controlled, including but not limited to infrastructure failures, space conditions (e.g., radiation, microgravity), natural disasters, human error, unauthorized third-party interference, or unplanned changes in regulatory or legal requirements.

By using the product, the user acknowledges awareness of the risks associated with its use in satellite and space applications and accepts full responsibility for the correct deployment and use of the product.