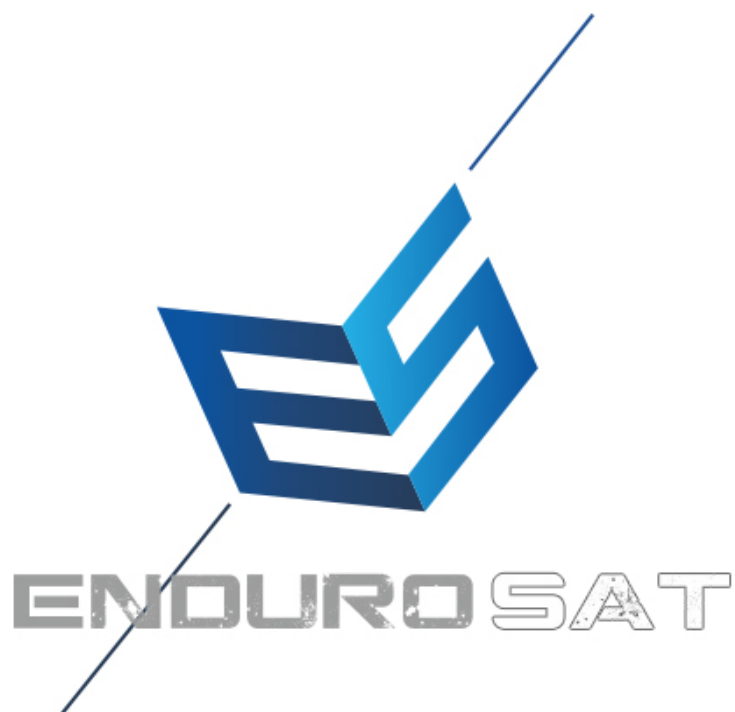




USER MANUAL

Onboard Computer (OBC) Type II

1	Change Log.....	4
2	Acronyms List.....	5
3	Description	6
4	Product Performance And Properties.....	6
5	Electrical Characteristic.....	7
6	Interface Diagram	8
7	Communication Interfaces	10
7.1	CAN.....	10
7.2	USART and UART	11
7.3	SPI.....	13
7.4	I ² C.....	14
7.5	Six General Purpose Outputs.....	14
8	Attitude determination and control system	14
8.1	Compass	14
8.2	Accelerometers	15
8.3	Sun sensors.....	15
8.4	Temperature sensors.....	15
8.5	Magnetorquers control	15
9	OBC ProtoBoard Area.....	16
9.1	USB interface.....	16
9.2	External PCB (Payload).....	17
9.3	Stripboard grid	18
9.4	Atomic Clock Ready	19
9.5	SD Card Holder.....	19
10	Connector pinout.....	20
10.1	Connectors location	20
10.2	H1 & H2 Stack Connector	21
10.3	PAN1, PAN2 and PAN3.....	23
10.4	PAN4, PAN5 and PAN6.....	23
10.5	JP2	24
10.6	JP14	26
10.7	J1	26
10.8	JP15	27
10.9	CN1	28
10.10	SD1.....	28
10.11	P1	29

11	Mechanical Characteristics	30
12	Assembling.....	31
13	Envinronmental And Mechanical Tests	31
14	Included In The Shipment	31
15	Handling And Storage.....	31
16	Warnings	32

ONBOARD COMPUTER (OBC) TYPE II

USER MANUAL

This user manual is specially designed to detail the EnduroSat onboard computer (OBC) type II, functions and features.

Please read carefully the manual before unpacking the OBC in order to ensure safe and proper use.

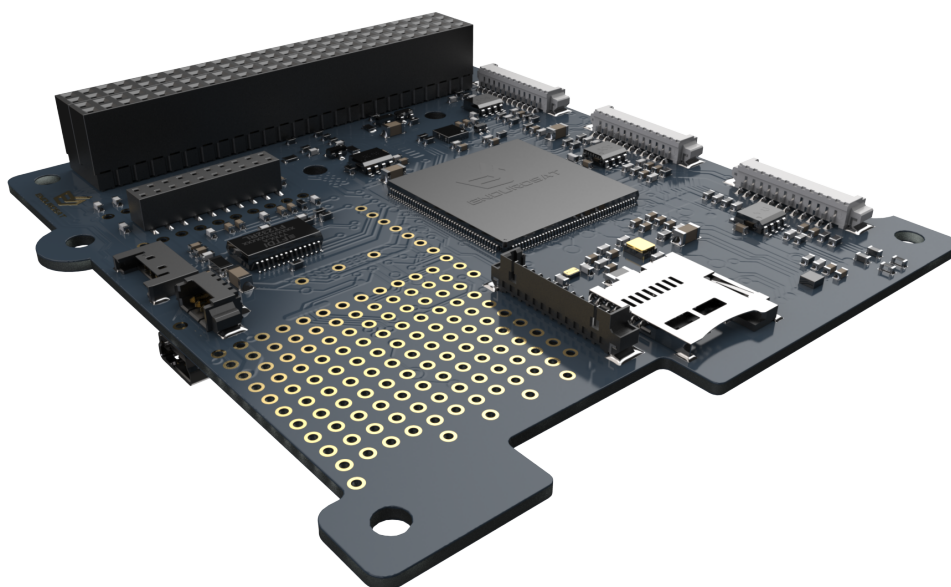


Figure 1 – Onboard computer (OBC) type II

1 CHANGE LOG

Date	Version	Note
20/06/2018	Rev 1	Initial document

2 ACRONYMS LIST

ASIC	Application Specific Integrated Circuit
CAN	Controller Area Network
COM-port	Communication Port
CSAC	Chip Scale Atomic Clock
ECSS	European Cooperation Space Standardization
ESA	European Space Agency
ESD	Electrostatic Discharge
GEVS	General Environmental Verification Standard.
GND	Ground
GPS	Global Positioning System
I2C	Inter-Integrated Circuit
OBC	Onboard Computer
PCB	Printed Circuit Board
PWM	Pulse Width Modulation
RAM	Random-Access Memory
RBF	Remove Before Flight
RF	Radio Frequency
SD card	Secure Digital Card
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver/Transmitter
UHF	Ultra-High Frequency
USART	Universal Synchronous Asynchronous Receiver Transmitter
USB	Universal Serial Bus

3 DESCRIPTION

The EnduroSat onboard computer type II is a low power consumption and high performance computing platform for nanosatellites, fully compatible with the CubeSat standard. It is based on ARM Cortex M4 with frequency rate up to 180MHz or optionally on ARM Cortex M7 processor with frequency rate up to 216 MHz. It comes with integrated double redundancy sensors: 3-Axis accelerometers and compass. PWM drivers for magnetorquers and inputs for sun sensors, temperature sensors and gyroscope allow the implementation of the attitude determination and control systems.

Customized interfaces and connectors allow high flexibility of the unit.

A Protoboard area on the PCB allows high customization ideal for test bed and fast prototyping. It is possible to connect additional PCB through connectors and mounting holes and to integrate easily additional sensors and chips such as atomic clocks, GPS receiver and so on.

4 PRODUCT PERFORMANCE AND PROPERTIES

- ARM Cortex M4/M7 processor;
- Frequency rate: up to 180 MHz for M4, up to 216 MHz for M7;
- 2MB Program Memory Size; 256kB RAM for M4, 2MB RAM for M7; 2048kB flash memory;
- MicroSD card slot;
- Integrated double redundancy sensors: 3-axis accelerometer and compass;
- 3x PWM drivers for magnetorquers;
- 6x analog inputs for sun sensor;
- 6x external temperature sensors can be connected;
- Three external gyroscope can be connected
- Interfaces: CAN, 2x USART, UART, 2x I2C, 2x SPI, USB (VCP);
- Real Time Clock
- Flexible frequency eco-mode;
- Weight: 58 g.
- 1Gbit Serial NOR Flash Memory
- 64Mbit Static RAM (Optional)
- Connector for antenna deployment
- ProtoBoard area for easy connection of payload and access to main power and communication busses.

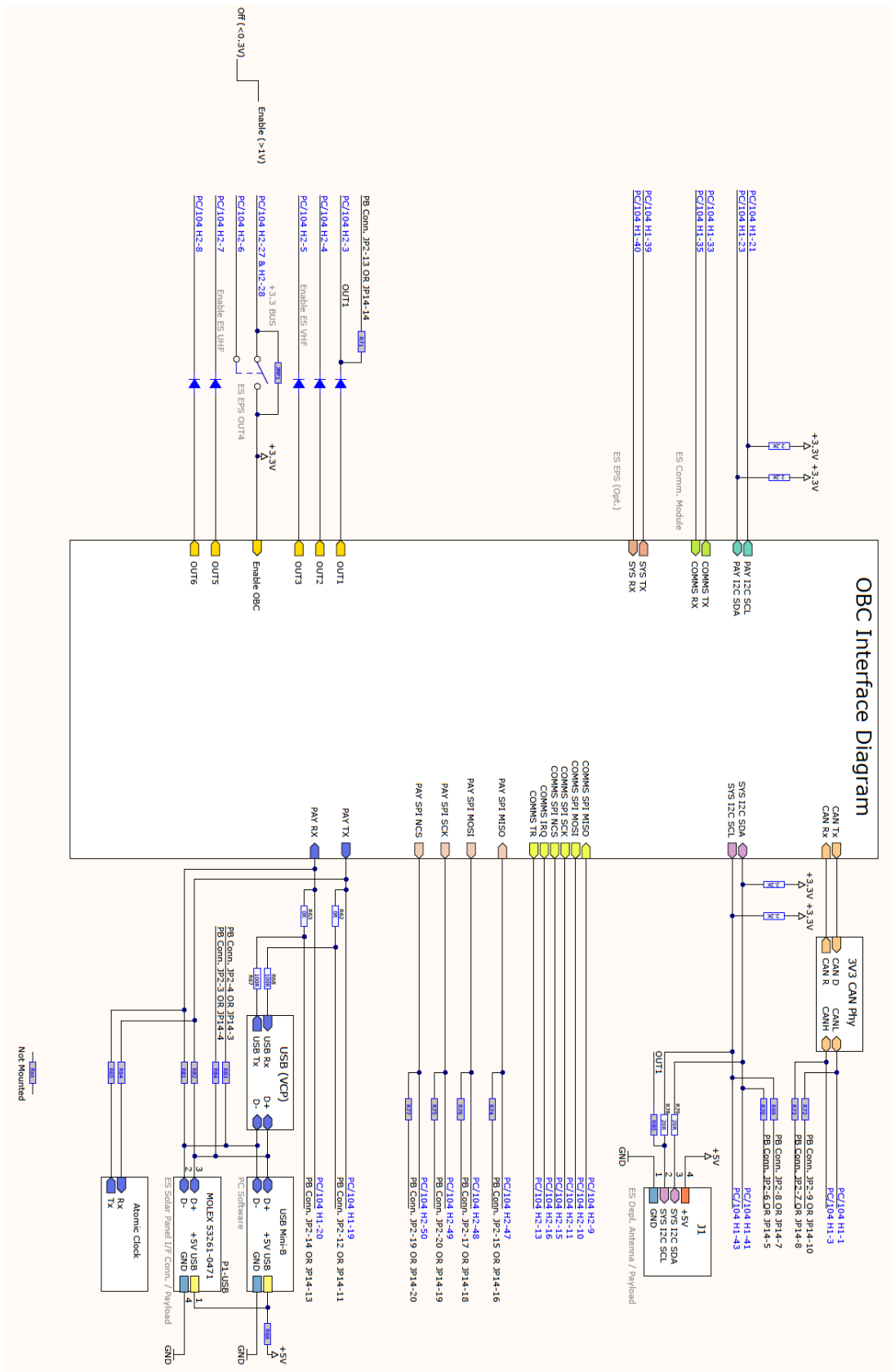
5 ELECTRICAL CHARACTERISTIC

Parameter	Unit	Condition	Min	Typ	Max
Supply voltage	V		3	3.3	3.6
Supply current	mA	STM32F427 @185Mhz		104	123
	mA	STM32F427 @120Mhz		58	72
	mA	STM32F427 @60Mhz		30	38
	mA	STM32F427 @16Mhz		13	27
	µA	3-Axis Accelerometer – Normal Mode ¹	200		400
	µA	3-Axis Accelerometer – Low Power Mode ¹	8		12
	µA	3-Axis Accelerometer – Power Down Mode ¹	0.1		2
	µA	3-Axis Digital Compass – Power Down Mode ²		1	
	µA	3-Axis Digital Compass - Measurement Mode ² – Low Power Mode		40	
		3-Axis Digital Compass - Measurement Mode ² – High Resolution Mode		280	
	mA	Ext. 64M-bit Static RAM (Opt.), F = 18Mhz		45	55
	mA	Ext. 64M-bit Static RAM (Opt.), F = 1Mhz		7.5	9
	µA	Ext. 64M-bit Static RAM (Opt.), Stand-By Mode		8	48
	mA	Ext. 1Gbit NOR Flash Memory Operational Mode @108Mhz (fast-read extended I/O)		4	15
	mA	Ext. 1Gbit NOR Flash Memory Operational Mode @54Mhz (fast-read extended I/O)		6	6
	mA	Ext. 1Gbit NOR Flash Memory Operational Mode @108Mhz (fast-read dual I/O)			18
	mA	Ext. 1Gbit NOR Flash Memory Operational Mode @108Mhz (Operating current (fast-read quad I/O)			20
	µA	Ext. 1Gbit NOR Flash Memory Operational Mode Stand by Mode			200
Bi-directional PWM Outputs	mA	@3.3V			3000
Operating Temperature	°C		-30		85
Storage Temperature	°C			25	

¹ - Current consumption is for one 3-Axis Accelerometer. The OBC has two identical sensors on the same location, but on opposite sides of the PCB.

² - Current consumption is for one 3-Axis Digital Compass. The OBC has two identical sensors on the same location, but on opposite sides of the PCB

6 INTERFACE DIAGRAM



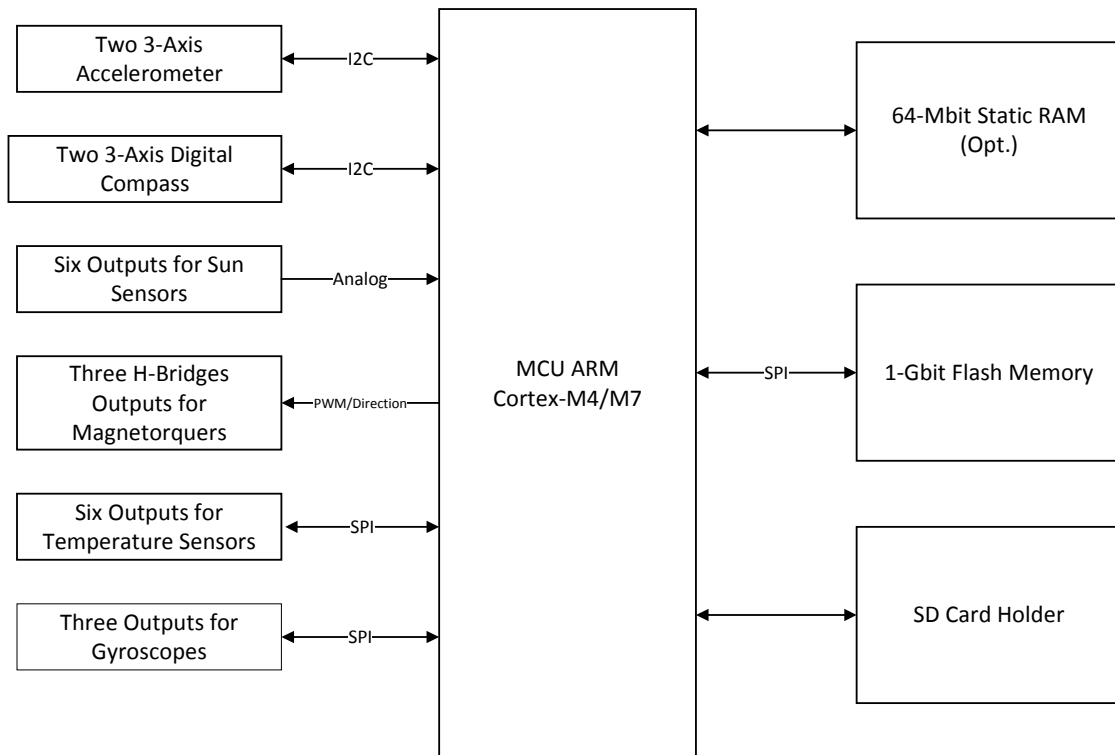


Figure 2 – OBC microcontroller periphery

7 COMMUNICATION INTERFACES

7.1 CAN

The EnduroSat On-board computer has a CAN bus interface using a 3.3-V CAN transceiver.

External modules can be connected throughout H1-1 and H1-3 of the PC/104 connector. Same interface can be reached from the ProtoBoard area through JP2 and JP14 connectors (TLE-110-01-G-DV), for this purpose zero Ohm resistors R72 and R73 should be mounted as shown in Figure 4.

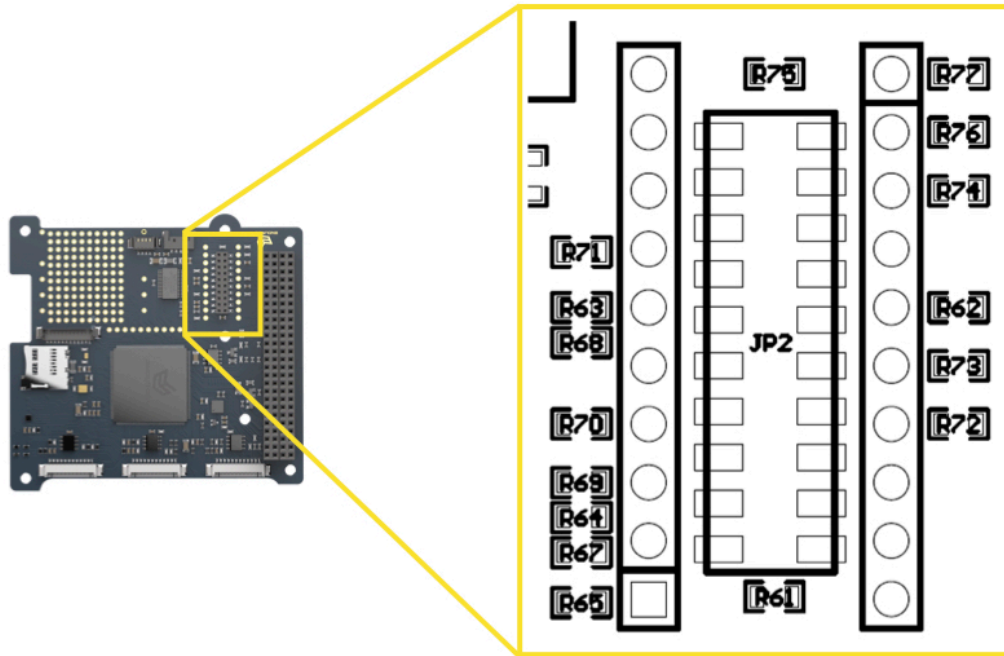


Figure 3 – ProtoBoard area customization

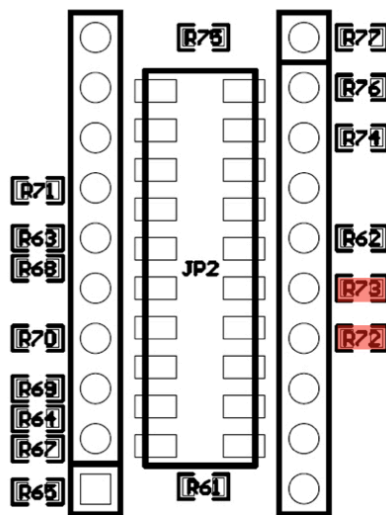


Figure 4

7.2 USART and UART

The EnduroSat onboard computer provides two USART and one UART interfaces.

The first USART interface (H1-33 and H1-35) is used by the UHF transceiver of the EnduroSat platform.

Second USART interface is left free for the payload (H1-19 and H1-20). If the USB peripheral is mounted (Figure 5), this interface is used for UART to USB communication (Virtual COM Port).

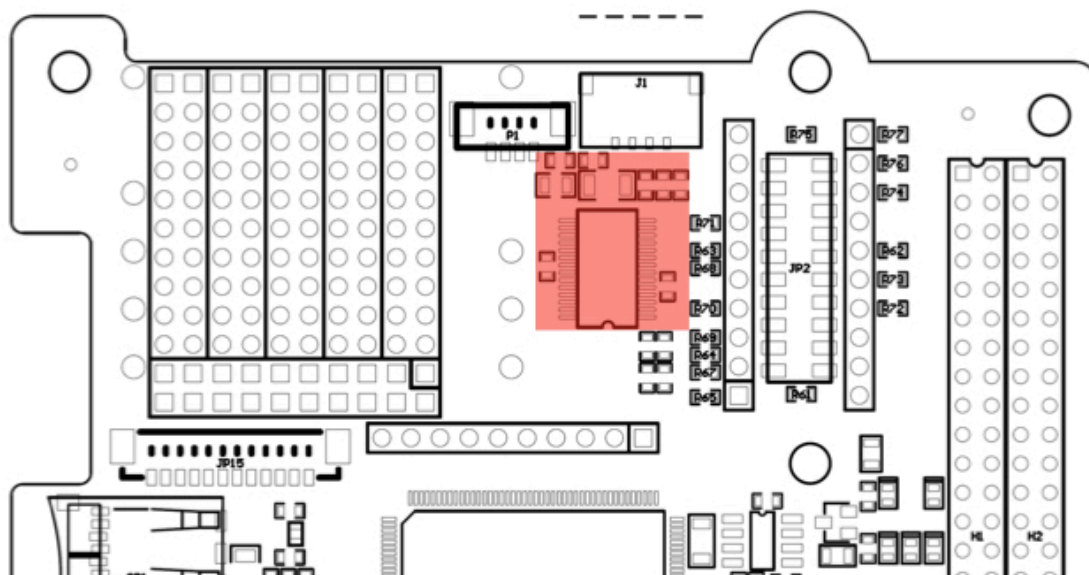


Figure 5 – USB peripheral location

Mounting zero Ohm resistors on R62 and R63 gives access to this interface through the connectors JP2 or JP14 on the ProtoBoard as shown in Figure 6.

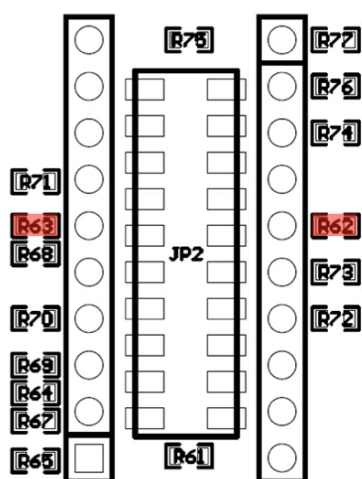


Figure 6

For USB (VCP) R62, R63, R67 & R68 as shown on figure 7

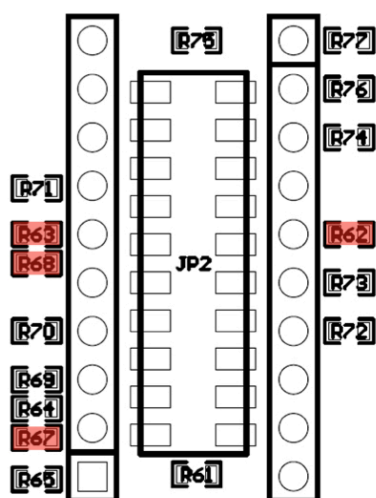


Figure 7

For USART on “P1-USB” R82, R81 as shown on figure 8.

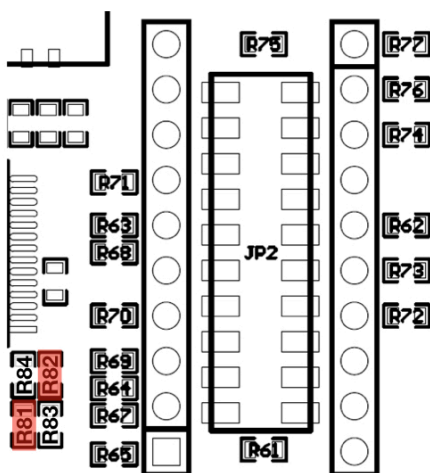


Figure 8

Moreover, the same interface can be used for communication with atomic clock if it is mounted on the ProtoBoard area (Microsemi Quantum™ SA.45s CSAC). To realize the communication with the atomic clock, zero ohm resistors – R62, R63, R64 and R65 have to be mounted as shown in Figure 9.

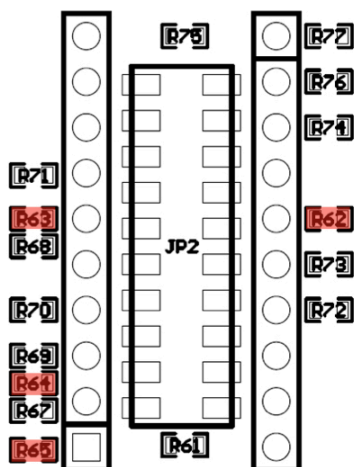


Figure 9

UART – is free for payload and it can be access through H1-39 / H1-40 (EnduroSat EPS Opt.).

7.3 SPI

Two 3.3V SPI interfaces are provided.

In the EnduroSat CubeSat platform the first SPI interface (H2-9, H2-10, H2-11, H2-15 and H2-16 of the PC104 connector) is used for the EnduroSat S-Band transceiver.

The second SPI interface (H2-47, H2-48, H2-49 and H2-50 of the PC104 connector) can be used for the payload or for generic user needs.

The second SPI interface also can be accessed through JP2 or JP14 of the ProtoBoard area mounting zero Ohm resistors R74, R75, R76 and R77 as shown in Figure 10.

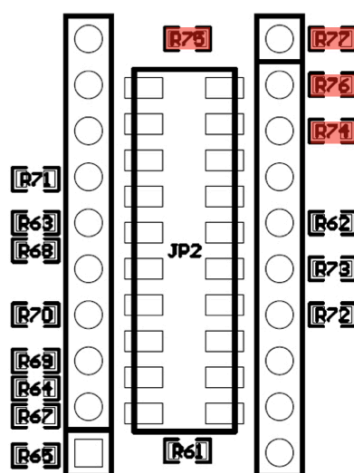


Figure 10

7.4 I²C

Two 3.3V I²C interfaces are provided.

First I²C interface (H1-41 and H1-43 of the PC104 connector) can be used as main interface among all the subsystems of the satellite.

Second I²C interface (H1-21 and H1-23 of the PC104 connector) can be used for the payload and to control the deployment of the EnduroSat UHF Antenna through the connector J1 located on the ProtoBoard area. To realize the access through JP2 or JP14, zero Ohm resistors R69 and R70 and have to be mounted (Figure 11).

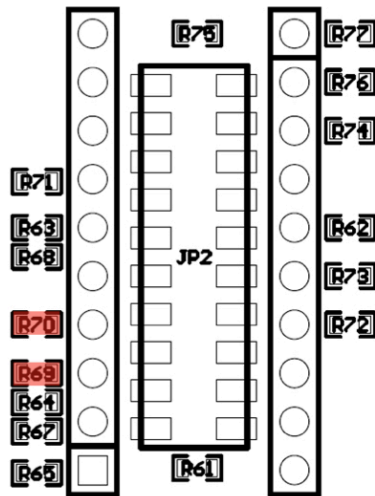


Figure 11

7.5 Six General Purpose Outputs

The OBC Module has five general purpose outputs. Each output can be switched between 3.1V and Ground. All outputs are protected with diodes. In this way other modules can control the same outputs (there are 10k pull-down resistors on the EnduroSat EPS Type I Module). Diode OR gate can be realized.

8 ATTITUDE DETERMINATION AND CONTROL SYSTEM

The EnduroSat Onboard computer comes with an embedded array of sensors for the attitude determination and outputs for magnetorquers control.

8.1 Compass

Two 3-axis digital compass designed for low-field magnetic sensing with high-resolution are added to the OBC periphery. Both sensors are located at the same place, but on opposite sides of the OBC. The compass is based on magneto-resistive sensors plus an ASIC containing amplification, automatic

degaussing strap drivers, offset cancellation, and a 12-bit ADC that enables 1° to 2° compass heading accuracy. Compass utilizes Anisotropic Magneto-resistive (AMR) technology that provides advantages over other magnetic sensor technologies. These anisotropic, directional sensors feature precision in-axis sensitivity and linearity. These sensors' solid-state construction with very low cross-axis sensitivity is designed to measure both the direction and the magnitude of Earth's magnetic fields, from milli-gauss to 8 gauss.

8.2 Accelerometers

Two high-performance ultra low-power 3-axis accelerometers are added to OBC periphery. Both of them are placed at the same location but on opposite site of the PCB. Accelerometers has dynamic user-selectable full-scales of $\pm 2g/\pm 4g/\pm 8g$ and is capable of measuring accelerations with output data rates from 0.5 Hz to 1 kHz

8.3 Sun sensors

Six analog inputs for sun sensors. At the current OBC design filters and amplification is optimized to EnduroSat Solar Panels Sun Sensors.

8.4 Temperature sensors

Six external temperature sensors with SPI communication interface can be connected to the OBC.

8.5 Magnetorquers control

Three independent outputs for control the magnetorquers. The control of magnetorquers is realised with H-Bridge with 3.3V and maximum output current of 3A.

Sensor	Parameter	Unit	Condition	Min	Typ	Max
Two 3-Axis Digital Compass						
	Measurement Range	gauss	Full scale	-16		+16
	Sensitivity	LSb/gauss	± 4		6842	1370
			± 8		3421	
			± 12		2281	
			± 16		1711	
Two 3-Axis Accelerometer						
	Measurement range				$\pm 2g/\pm 4g/\pm 8g$	
	Output Data Rate	Hz		0.5		1000

9 OBC PROTOBOARD AREA

9.1 USB interface

Additional USB interface can be provided on the ProtoBoard area. This interface gives accessibility to an external device/PC (Master device) to communicate with the OBC Microcontroller (Slave device). OBC USB interface is based on IC FT232RL - UART to USB interface (Virtual COM Port). Full driver support can be found at <http://www.ftdichip.com>.

The EnduroSat On-Board Computer type II comes with electronic components for USB Interface already mounted on it.

The USB interface can be accessed from PC/104 connector (Tx) H-19 and (Rx) H-20. Moreover, it can be also accessed from 20pin headers “JP2” of the top side of the OBC through 11pin Rx/12pin Tx or “JP14” from bottom side through 12pin Rx / 11pin Tx. To realize the access through “JP2” and “JP14”, zero Ohm resistors R62, R63, R67 and R68 have to be mounted as shown in Figure 7.

Two types of connectors can be used to access the USB Interface: standard USB Mini B Connector (USB1) or Molex 53398-0471 (P1). When EnduroSat Solar Panel with RBF and interface connector are used in the platform, connection through it and the OBC Molex 53398-0471 can be realized with EnduroSat 4 pin cable. In this way the OBC USB interface can be accessed with the external EnduroSat USB adapter also when the CubeSat is fully assembled. Both USB connectors can be connected to the ProtoBoard Connectors “JP2” (DM – pin3 / DP – pin4) and “JP14” (DM – pin4 / DP – pin3) when zero Ohm resistors are mounted on R83 and R84 (Figure 12).

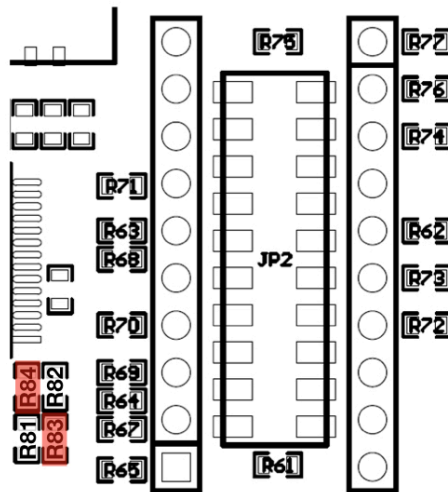


Figure 12

9.2 External PCB (Payload)

External PCB (Payload) can be connected to the connector located on the ProtoBoard Area. Additional mounting holes are also provided. The ProtoBoard connector is the 20pin SAMTEC TLE-110-01-G-DV. One is on the top side (JP2) of the OBC and the other on the bottom (JP14 -Not Mounted). This allows to minimize the used space inside the satellite and easily access to different communication interfaces and power supply. The interfaces on the ProtoBoard connectors should be chosen very carefully, because they are shared between with main PC/104 connector. All pins of ProtoBoard connectors are separated from the rest of the OBC when zero Ohm resistors are not mounted. Each pin of the ProtoBoard connector has its own testing point located just next to it for research and developing purposes. All test points are plated holes with pitch 0.1inch (2.54mm) and diameter of 0.060inch.

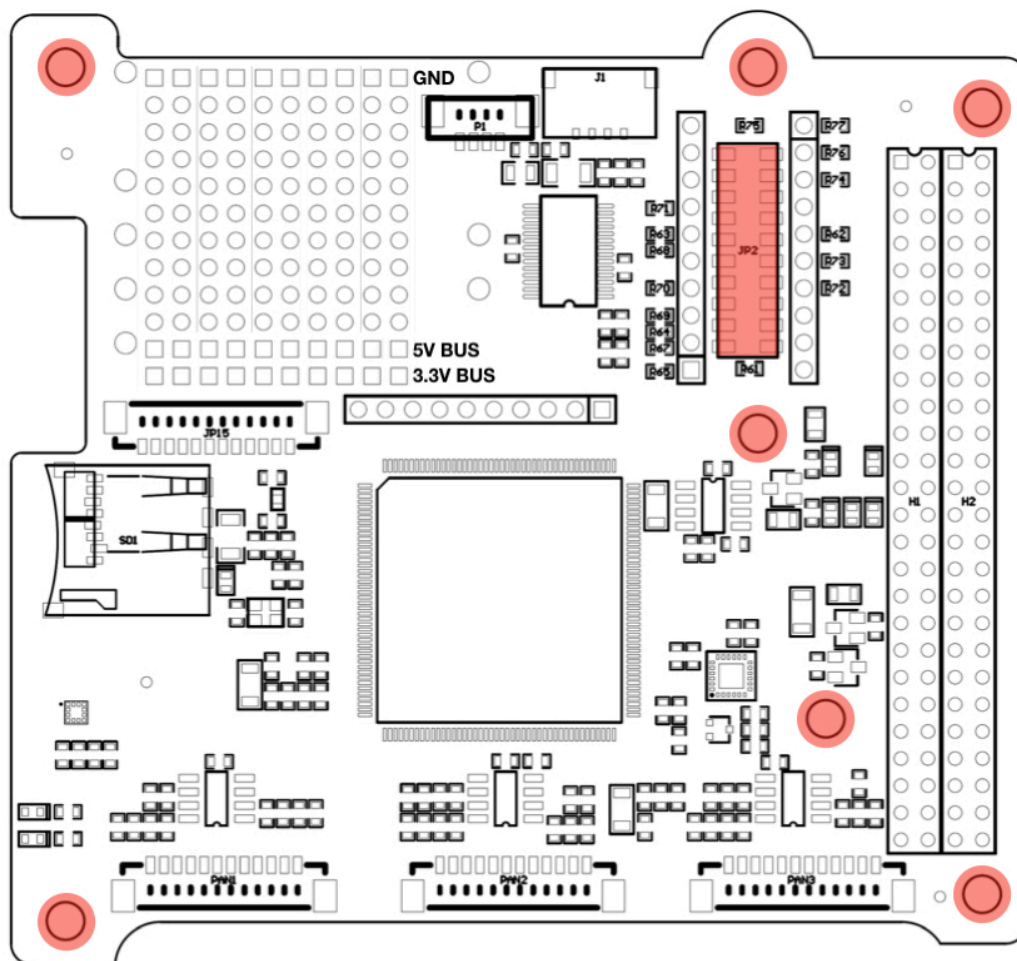


Figure 13 – External PCB

9.3 Stripboard grid

For developing and prototyping purposes an area of OBC is left as a stripboard grid with 11 holes on 16 strips. All holes are plated with grid spacing of 0.1inch(2.54mm) and diameter of 0.060inch. All holes in the first strip are connected to the 5V BUS, in the second strip to 3.3V BUS and the last one to GND. These power strips can be recognized by the square rings.

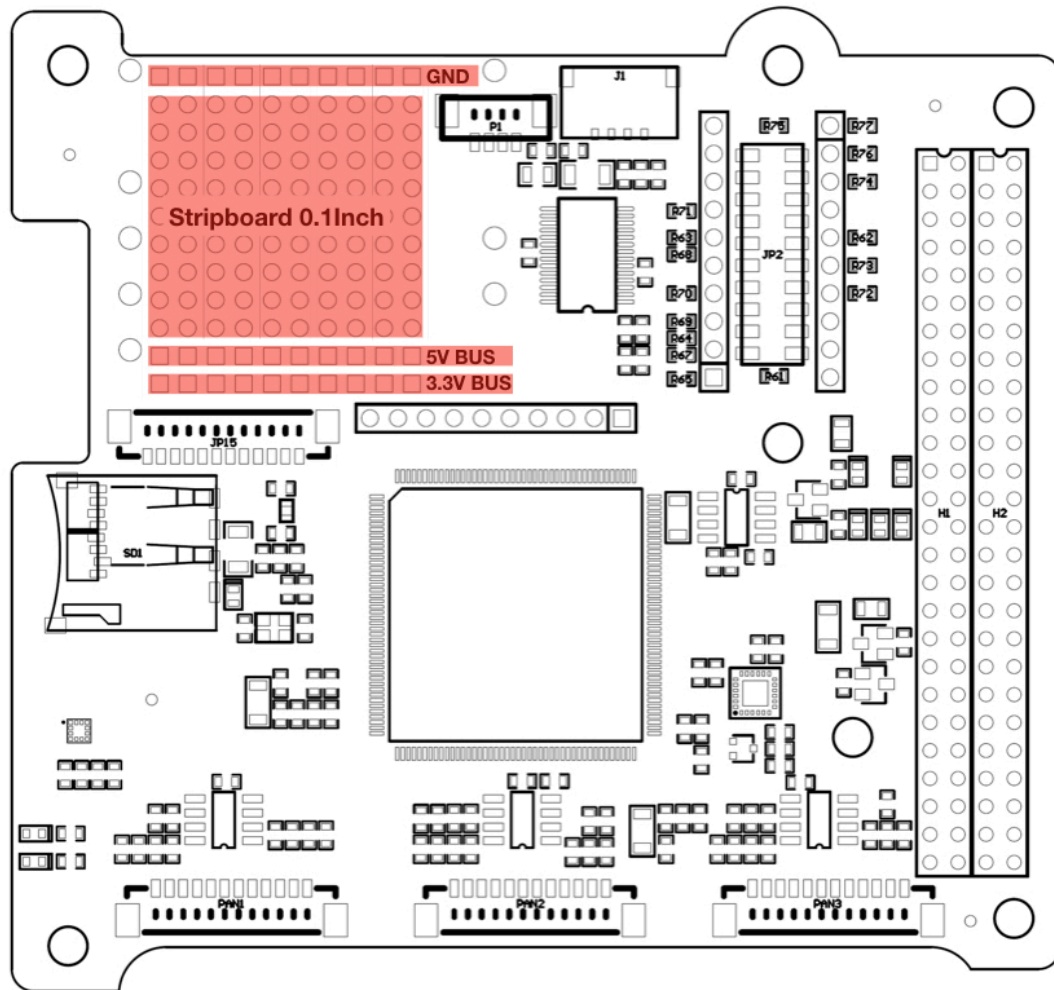


Figure 14

9.4 Atomic Clock Ready

On the protoboard area, there are mounting holes for Quantum™ SA.45s Chip Scale Atomic Clock (CSAC) from Microsemi. UART interface can be connected through zero Ohm resistors. Access to other pins of the atomic clock can be realized with plated holes next to each pin.

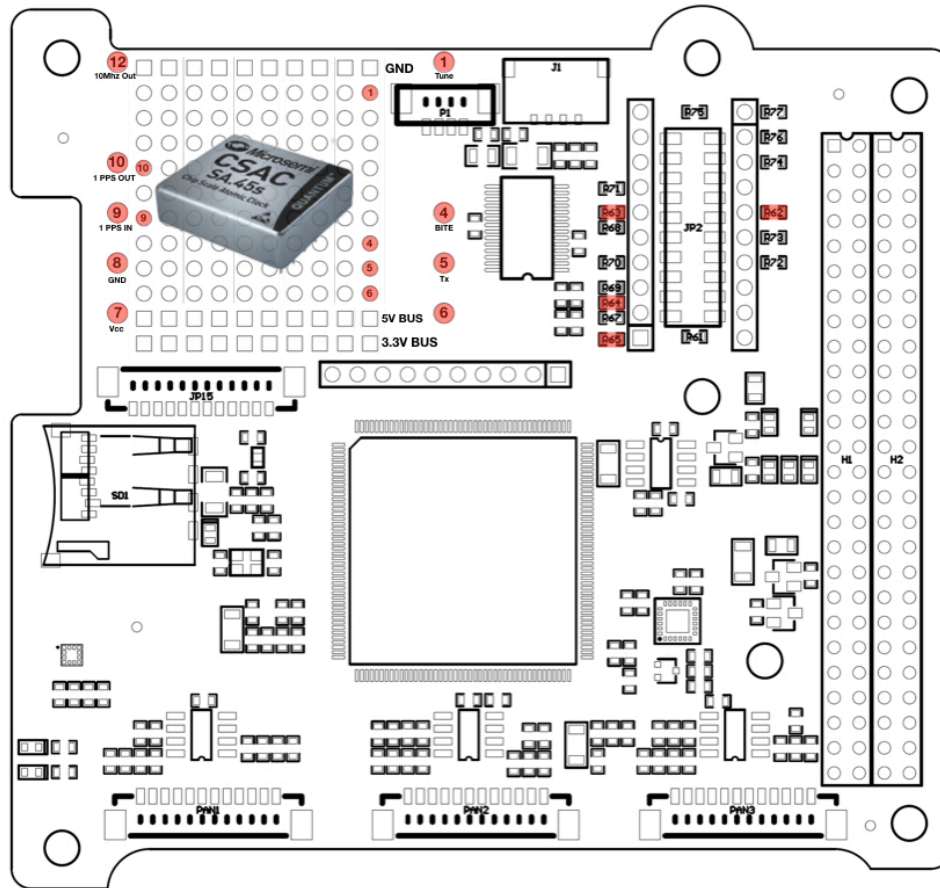


Figure 15

9.5 SD Card Holder

Direct access to SD Card holder is enable through 12pin connector JP15 – Molex 53398-1271. The SD card is shared between high speed data payload and OBC to resend trough the RF communication module.

10 CONNECTOR PINOUT

10.1 Connectors location

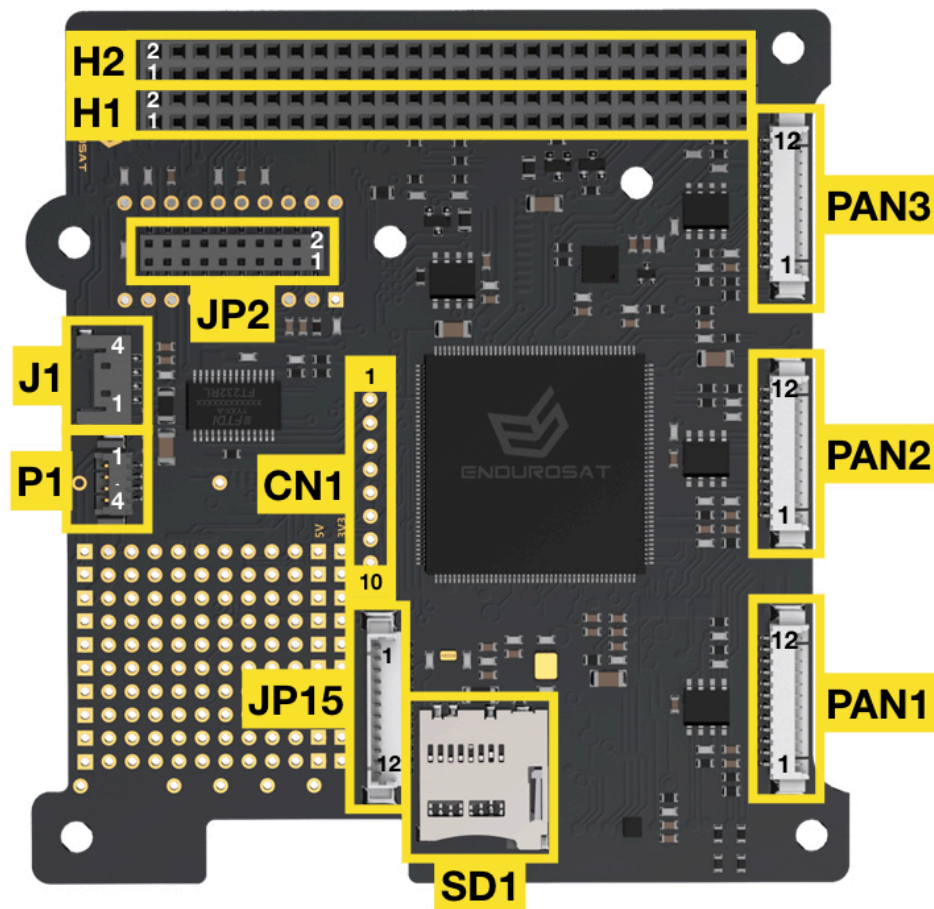


Figure 16 - OBC - top side - Connectors location

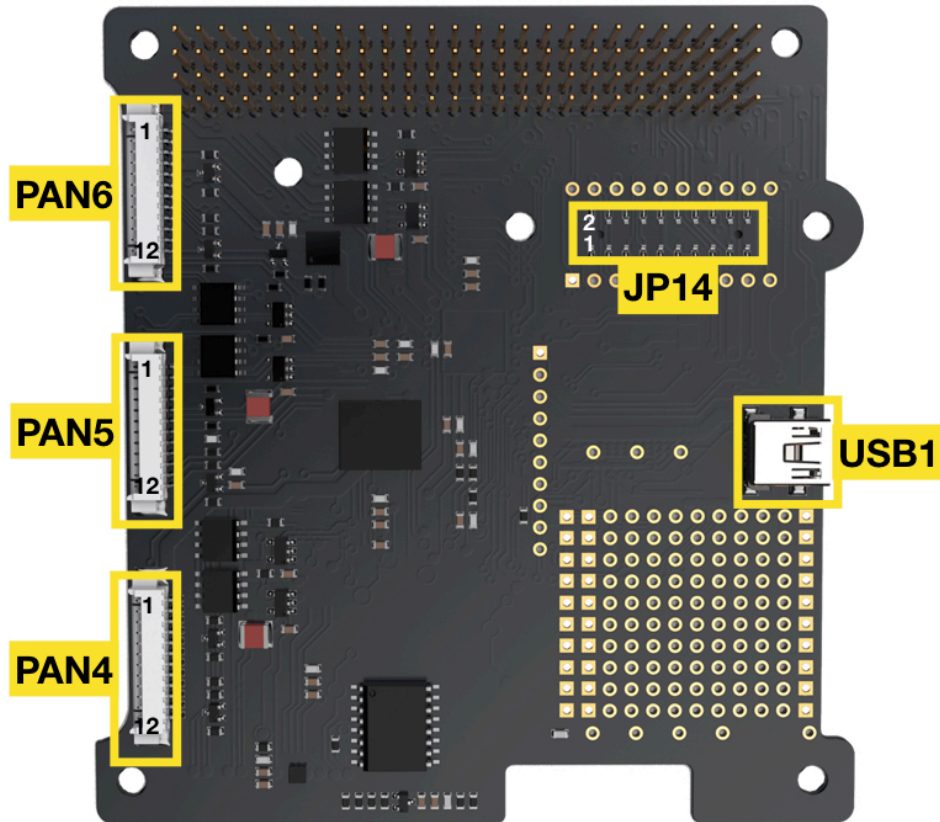
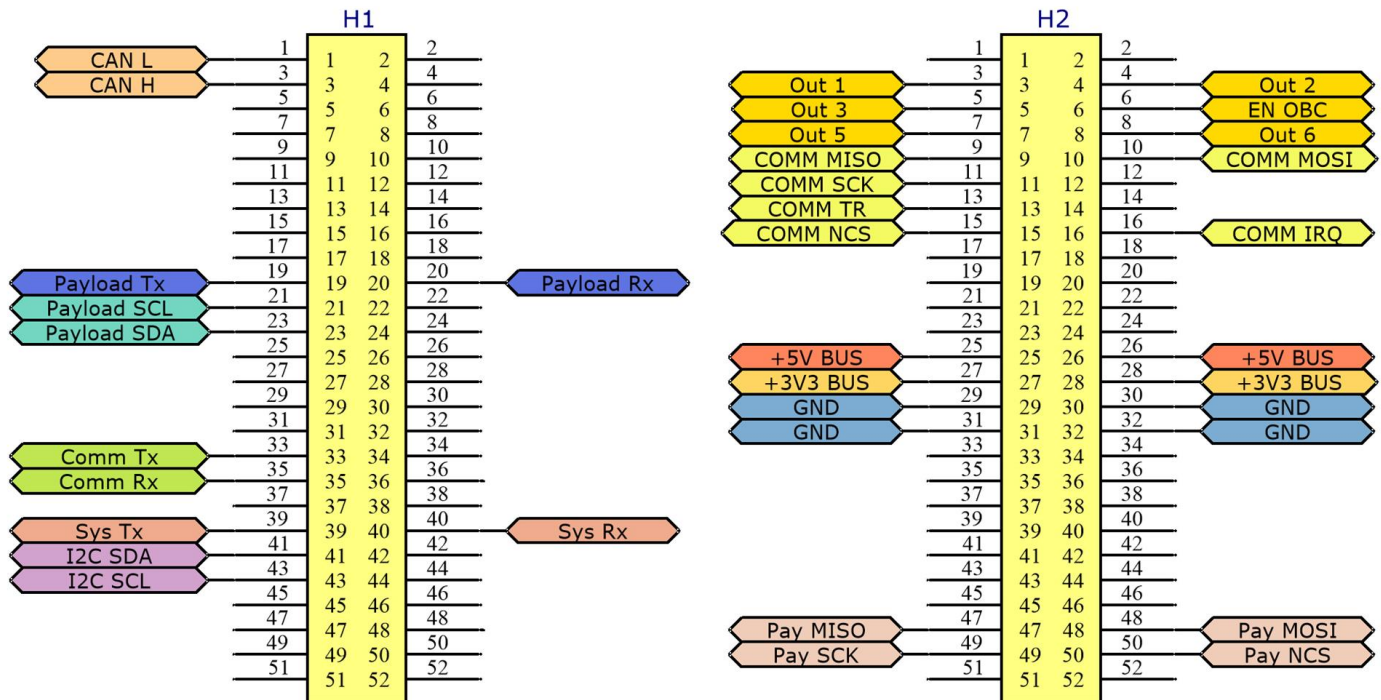


Figure 17 - OBC – bottom side - Connectors location

10.2 H1 & H2 Stack Connector



H1

Pin	Mnemonic	Description
H1-1	CANL	CAN communication Low (3.3V)
H1-3	CANH	CAN communication High (3.3V)
H1-19	PAY_TX	USART payload transmit data
H1-20	PAY_RX	USART payload receive data
H1-21	PAY_SCL	I2C for payload
H1-23	PAY_SDA	I2C for payload
H1-33	UHF RX	USART UHF module transmit data (optional EnduroSat EPS)
H1-35	UHF TX	USART UHF module receive data (optional EnduroSat EPS)
H1-39	SYS_TX	UART transmit data
H1-40	SYS_RX	UART receive data
H1-41	SYS_SDA	I2C between sub-systems
H1-43	SYS_SCL	I2C between sub-systems

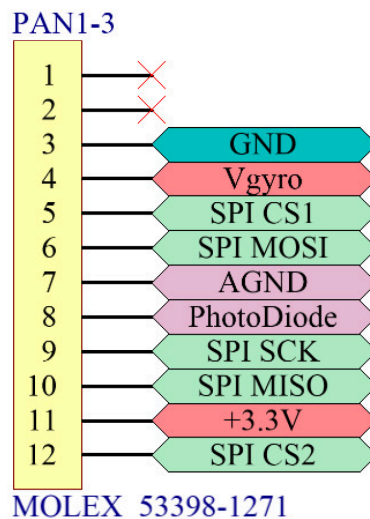
H2

Pin	Mnemonic	Description
H2-3	OBC_OUT1	Universal Output 1
H2-4	OBC_OUT2	Universal Output 2
H2-5	OBC_OUT3	Universal Output 3
H2-6	EN_OBC	Enable OBC (to turn on the OBC)
H2-7	OBC_OUT5	Universal Output 5
H2-8	OBC_OUT6	Universal Output 6
H2-9	SPI MISO	SPI MISO
H2-10	SPI MOSI	SPI MOSI
H2-11	SPI SCK	SPI SCK
H2-13	SPI TR	SPI TR
H2-15	SPI CS	SPI CS
H2-16	SPI IRQ	SPI IRQ
H2-25	+5V	+5V BUS
H2-26	+5V	+5V BUS
H2-27	3V3	+3.3V BUS
H2-28	3V3	+3.3V BUS
H2-29	GND	Ground
H2-30	GND	Ground
H2-31	GND	Ground
H2-32	GND	Ground

H2-47	PAY_MISO	SPI Payload
H2-48	PAY_MOSI	SPI Payload
H2-49	PAY_SCK	SPI Payload
H2-50	PAY_NCS	SPI Payload

10.3 PAN1, PAN2 and PAN3

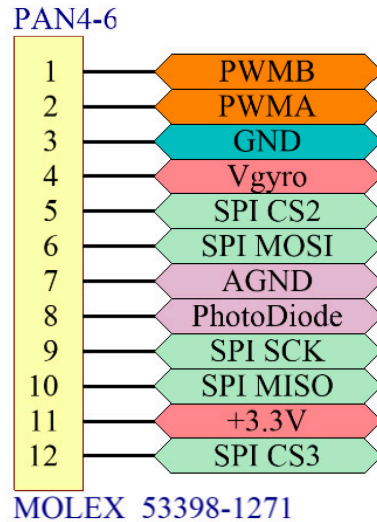
Picoblade 12 pins connectors PAN1, PAN2 and PAN3 are located on the top side of the OBC as shown in Figure 16.



Pin	Mnemonic	Description
1	NC	Not connected
2	NC	Not connected
3	GND	Ground
4	Vgyro	Power for gyroscope
5	SPI CS1	SPI chip select for gyroscope
6	SPI MOSI	SPI (for gyroscope and temperature sensor)
7	AGND	Photodiode Analog Ground
8	PhotoDiode	Photodiode signal
9	SPI SCK	SPI (for gyroscope and temperature sensor)
10	SPI MISO	SPI (for gyroscope and temperature sensor)
11	+3.3V	+3.3V BUS power supply for sensors
12	SPI CS2	SPI chip select for temperature sensor

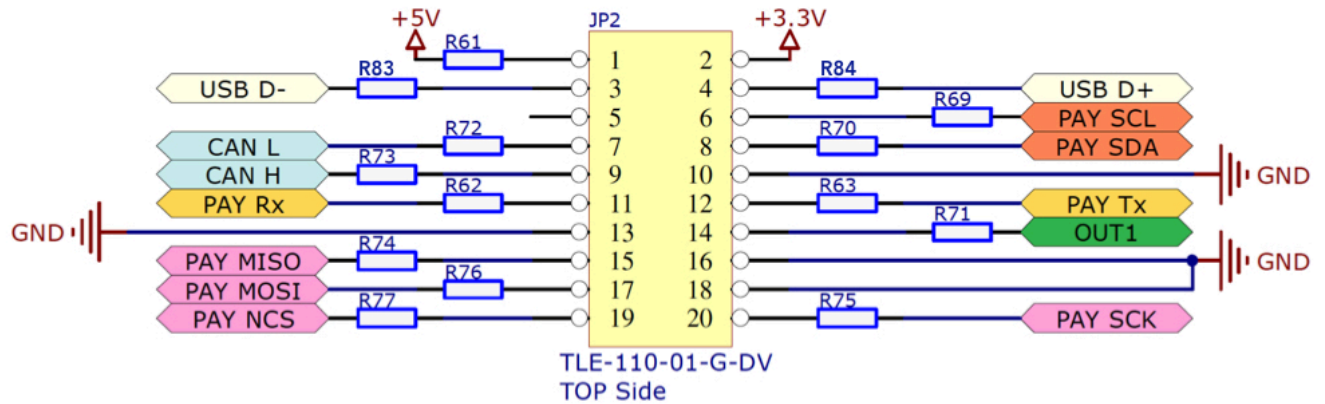
10.4 PAN4, PAN5 and PAN6

Picoblade 12 pins connectors PAN4, PAN5 and PAN6 are located on the bottom side of the OBC as shown in Figure 17.



Pin	Mnemonic	Description
1	PWMB	PWM (in/out)
2	PWMA	PWM (out/in)
3	GND	Ground
4	Vgyro	Power for gyroscope
5	SPI CS1	SPI chip select for gyroscope
6	SPI MOSI	SPI (for gyroscope and temperature sensor)
7	AGND	Photodiode Analog Ground
8	PhotoDiode	Photodiode signal
9	SPI SCK	SPI (for gyroscope and temperature sensor)
10	SPI MISO	SPI (for gyroscope and temperature sensor)
11	+3.3V	+3.3V BUS power supply for sensors
12	SPI CS2	SPI chip select for temperature sensor

10.5 JP2



JP2		
Pin	Mnemonic	Description
1	+5V	+5V BUS
2	+3.3V	+3.3V BUS
3	USB D-	USB data -
4	USB D+	USB data +
5		Not connected
6	PAY SCL	I2C payload
7	CAN L	CAN Low (3.3V)
8	PAY SDA	I2C payload
9	CAN H	CAN High (3.3V)
10	GND	Ground
11	PAY Rx	USART receive data
12	PAY Tx	USART transmit data
13	GND	Ground
14	OUT1	Universal output 1
15	PAY MISO	SPI payload
16	GND	Ground
17	PAY MOSI	SPI payload
18	GND	Ground
19	PAY NCS	SPI payload
20	PAY SCK	SPI payload

10.6 JP14

JP14		
Pin	Mnemonic	Description
1	+3.3V	+3.3V BUS
2	+5V	+5V BUS
3	USB D+	USB data +
4	USB D-	USB data -
5	PAY SCL	I2C payload
6		Not connected
7	PAY SDA	I2C payload
8	CAN L	CAN Low (3.3V)
9	GND	Ground
10	CAN H	CAN High (3.3V)
11	PAY Tx	USART transmit data
12	PAY Rx	USART receive data
13	OUT1	Universal output 1
14	GND	Ground
15	GND	Ground
16	PAY MISO	SPI payload
17	GND	Ground
18	PAY MOSI	SPI payload
19	PAY SCK	SPI payload
20	PAYNCS	SPI payload

10.7 J1

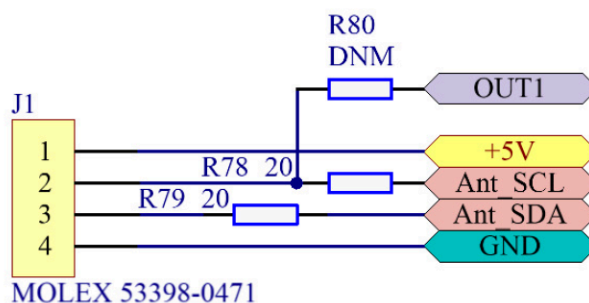
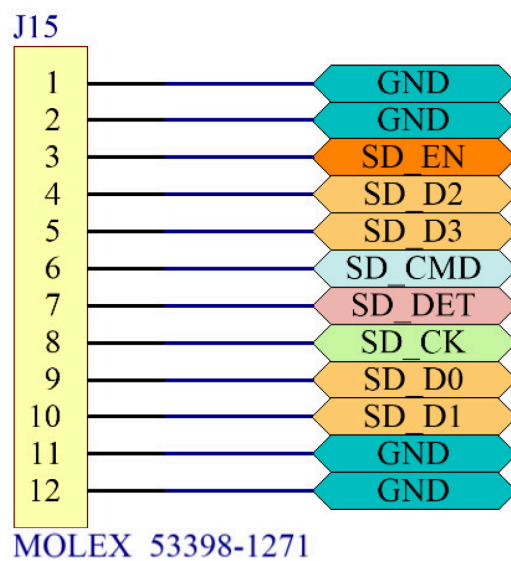


Figure 18

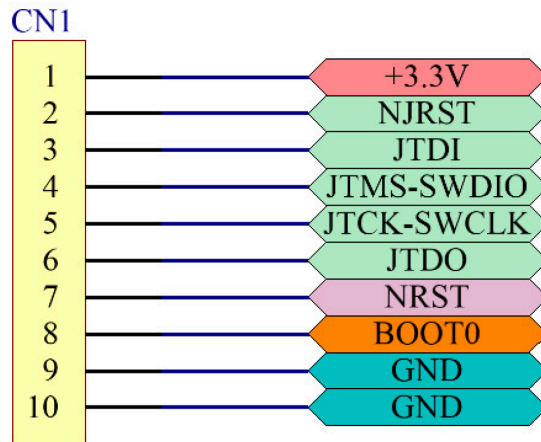
J1		
Pin	Mnemonic	Description
1	+5V	+5V BUS
2	Ant_SCL / OUT1	I2C UHF antenna / Universal output 1
3	Ant_SDA	I2C UHF antenna
4	GND	Ground

10.8 JP15



Pin	Mnemonic	Description
1	GND	Ground
2	GND	Ground
3	SD_EN	SD Enable
4	SD_D2	SD data 2
5	SD_D3	SD data 3
6	SD_CMD	SD command I/O
7	SD_DET	SD detect
8	SD_CK	SD clock
9	SD_D0	SD data 0
10	SD_D1	SD data 1
11	GND	Ground

12	GND	Ground
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10.9 CN1

Pin	Mnemonic	Description
1	+3.3V	+3.3V BUS
2	NJRST	JTAG Test nReset
3	JTDI	JTAG Test Data Input
4	JTMS-SWDIO	JTAG Test Mode Selection / Serial Wire Data I/O
5	JTCK-SWCLK	JTAG Test Clock / Serial Wire Clock
6	JTDO	JTAG Test Data Output
7	NRST	External Reset
8	BOOT0	Boot Configuration
9	GND	Ground
10	GND	Ground

10.10 SD1

Pin	Signal	Description
1	Data2	Data signal 1
2	Data3	Data signal 2
3	CMD I/O	input and output command
4	GND	supply voltage negative
5	VDD	supply voltage positive
6	CLK	clock signal
7	GND	supply voltage negative
8	Data0	data signal 0
9	Data1	data signal 1

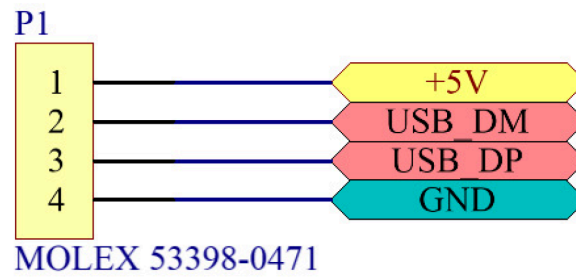
10.11 P1

Figure 19

Pin	Mnemonic	Description
1	+5V	+5V USB
2	USB_DM	USB data -
3	USB_DP	USB data +
4	GND	Ground

11 MECHANICAL CHARACTERISTICS

In the following paragraphs main dimensions of the Onboard Computer are shown. All dimensions are in mm. STEP file can be provided upon request.

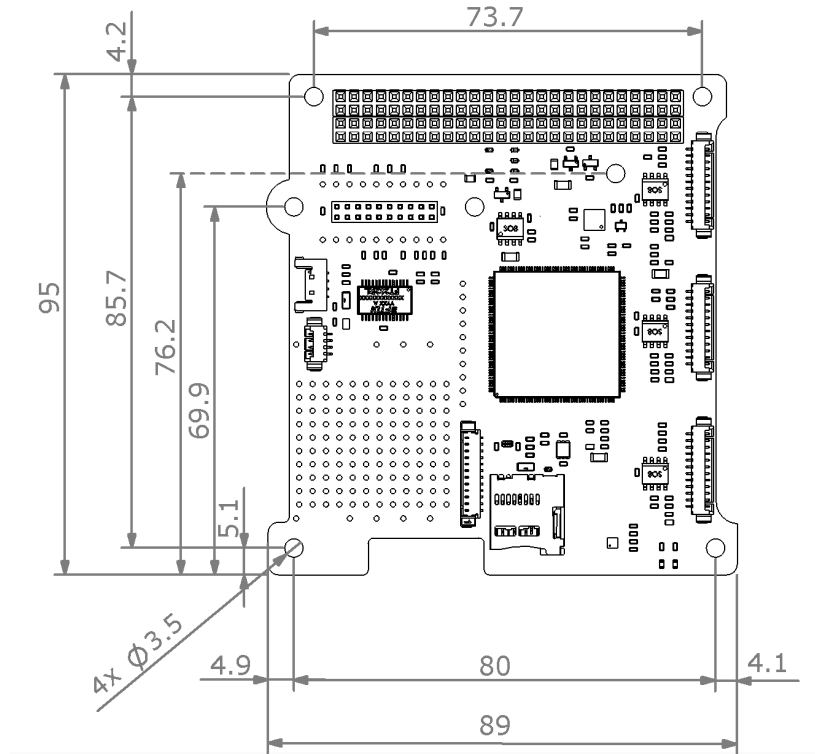


Figure 20 - OBC top view

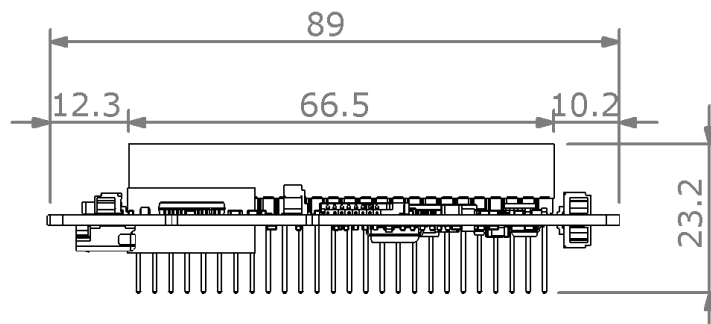


Figure 21 - OBC side view

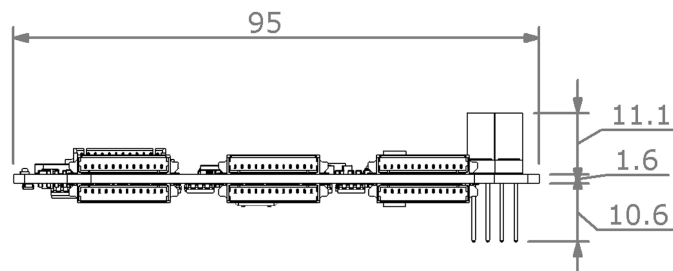


Figure 22 - OBC - side view

12 ASSEMBLING

Production process follows quality standard:

- PC-A-610E, class 3 (Acceptability of Electronic Assemblies)
- IPC-A-600 (Acceptability of printed boards)
- J-STD-001 (Requirements for Soldered Electrical and Electronic Assemblies)
- ISO 14644 (Cleanrooms and associated controlled environments)
- IEC 61340 (Electrostatics ESD: Protection of electronic devices from electrostatic phenomena)

Conformal coating:

- Outgassing requirements: NASA SP-R-0022A
- Thickness tolerance: NASA-STD-8793.

13 ENVIRONMENTAL AND MECHANICAL TESTS

A full campaign of tests at qualification level was performed on the onboard computer qualification engineering model. Qualification tests level and duration follow the ESA standard ECSS-E-ST-10-03C and GEVS: GSFC-STD-7000A. Test performed:

- Thermal Cycling
- Thermal Vacuum
- Random Vibration
- Sine Vibration
- Shock Test

Space qualification campaign link: <https://www.endurosat.com/space-qualification/>

14 INCLUDED IN THE SHIPMENT

EnduroSat provides along with the Onboard computer:

- USB drive with user manual
- JTAG programming cable

15 HANDLING AND STORAGE

Particular attention shall be paid to the avoidance of damage to the onboard computer during handling, storage and preservation. The handling of the on board computer module should be performed in compliance with the following instructions:

- Handle using PVC, latex, cotton (lint free) or nylon gloves.

- The environment where on board computer module will be handled shall meet the requirements for a class 100,000 environment, free of contaminants such dust, oil, grease, fumes and smoke from any source.
- Store in such a manner as to preclude stress and prevent damage.
- To prevent the deterioration, the power module must be stored in a controlled environment, i.e. the temperature and humidity levels shall be maintained in the proper ranges:
 - Ideal storage temperature range: 15°C to 27°C
 - Ideal storage humidity range: 30% to 60% relative humidity (RH)

16 WARNINGS



This product uses very fragile components. Observe precautions for Handling.



This product uses semiconductors that can be damaged by electrostatic discharge (ESD). Observe precautions for Handling



Sensitive Electronic device. Do not ship or store near strong electrostatic, electromagnetic, magnetic or radioactive fields.

