TRISKEL OBC-TTC

On Board Computer & TTC for nanosatellites

Datasheet

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1. Changelog

Table 1 - Changelog

Date	Revision	Author	Description
10/03/2021	1.0	BFA	First revision
02/07/2021	1.1	BFA	In Table 19: - I_{CC} values are changed from typical to to máximum OBC microcontroller is improved
26/07/2021	1.2	BFA	In 2: - Overview was updated In 2.2: - Modified TRISKEL block diagram In 3.2: - Updated Microcontroller specifications - Updated Watchdog features - Added SD Card chapter (3.2.10) In 3.3: - Updated Microcontroller specifications - Updated Watchdog features In 3.4: - Added new chapter 3.4 OBSW In 4.2: - Added new GPIO pins in H1 - Added new CAN_2 pins in H2 - Added new RS485 full duplex pines in P1 - Added new RS485 full duplex pines in P2 - Added new RS485 full duplex pines in P3 In 5: - Added new CAN bus interface - UART PL3 name and description was updated - RS485 buses name and description was updated General: - Some typo errors were updated
15/12/2021	1.3	BFA	In 2.1:

			- Modified: RS485 by RS422 - Added: SDRAM memory - Removed: “TBC” for switchable power for Flash, PWM and GNSS In 3.2: - Added: 3.2.5 SDRAM chapter (modified all following chapter names) - Modified: PWM to Magnetic torquer interface. In 4.2: - Modified and updated: System Bus specification - Updated: P1, P2, P3 pinouts - Updated: P5 alternative functionality - Updated: P8 pin out and chapter name - Updated: P14 connector In 5.3: - Updated: I2C 2 explanation In 5.4: - Updated: RS422 options In 5.6: - Updated: connector number In 6: - Updated: Power supply values - Updated: ADC max input voltage - Updated: PWM current In 7: - Updated: Maximum input current in OBC and TTC
21/02/2022	1.4	BFA	MRAM storage updated
24/05/2022	1.5	BFA	In 2: - Some interfaces updated - Architecture updated In 3: - Added more GPIO information In 4: - Connector layout updated - System Bus connections added “*” to all configurable pines

			- Updates RS422 pines in "payload" connectors In 6: - ADC data updated
11/07/2022	1.6	BFA	Removed some limitations of current version
26/10/2022	1.7	BFA	Added previously removed features.

2. Overview

TRISKEL is an OBC and TTC integrated in a single PC104 module for nanosatellites. It is based on a Cortex-M7 microcontroller for the OBC and another independent Cortex-M7 microcontroller for TTC that manages the radio interface.

The OBC is the subsystem in charge of executing the OBSW. In it, different tasks could be carried out such as monitoring the status of the satellite, following the schedule, executing the commands sent from the operators, storing information..., etc. The TRISKEL-OBC is based on a Cortex-M7 up to 280 MHz, a microcontroller with high clock frequency, to perform all the necessary tasks with low power consumption.

It has different types of sensors integrated to monitor the satellite's status: voltage, current, temperature sensors and an IMU. You also have the option of adding external sensors through an external I2C bus, such as solar panel sensors, for example, temperature sensors. TRISKEL-OBC includes the possibility to control 3-axis magnetic torquers through PWM signals.

In TRISKEL-OBC different types of memories are included for different purposes. Also 2 microSDs of up to 128GB to store large amounts of data.

The TTC is the subsystem in charge of communication with the earth station. The TRISKEL-TTC is based on a Cortex-M7 up to 280 MHz, with encryption capacity, in order to obtain secure communications. TRISKEL-TTC includes the frontend for UHF (400 MHz or 435 MHz bands), with an output power of 30dBm. The modulation used is GMSK, so the amplifier has high efficiency and low consumption. The reception chain has a LNA and a SAW filter to condition the received signal.

2.1. Highlight Features

- Interfaces:
    - 3xRS422 Full-Duplex
    - 1xUART for external communication
    - 2xCAN
    - 2xI2C
    - PPS
    - 15xGPIO in different connectors
    - 8xADC
    - 6xPWM over an H-Bridge
    - Umbilical connector with following interfaces:

        - CAN
        - OBC JTAG
        - 4xGPIOs
        - OBC UART for debugging
        - Multipurpose OBC UART
        - TTC UART for debugging
        - 2xUARTs for payload access
    - RF TX/RX for TTC
    - SPI
- On-Board Computer:
    - ARM Cortex-M7 CPU 32-bit
    - 2MB program flash memory
    - 1.4MB of internal RAM memory
    - 2xmicroSD card slot for massive storage
    - EEPROM for board configuration
    - RAM execution memory (SDRAM - 256 Mb)
    - Persistent memory (MRAM - 4 Mb)
    - Persistent memory for data storage (NAND Flash - 1 Gb)
    - Hardware watchdog and reset circuit
    - RTC with external power supply for time retention during power-downs
    - Switchable power for Flash, PWM H-Bridge, internal GNSS and an external independent power supply for external sensors.
    - Cryptographic capabilities (AES, HMAC)
- TTC:
    - ARM Cortex-M7 CPU 32-bit
    - 2MB program flash memory
    - 1.4MB of internal RAM memory
    - EEPROM for board configuration
    - Persistent memory for OBSW status (MRAM - 4 Mb)
    - Persistent memory for data storage (NAND Flash - 1 Gb)
    - Frequencies bands:
        - UHF (395 - 410 MHz)
        - UHF amateur (430 - 440 MHz)
    - Half-duplex communication
    - GFSK modulation (GMSK)
    - Data rates: 1.2 - 19.2 kbps
    - Transmission power: 30 dBm
    - PAE: 35%
    - Reception sensitivity: -123 dBm @ 1.2 kbps

    - Golay + Reed-Solomon codification
    - Hardware watchdog and reset circuit
    - Cryptographic capabilities (AES, HMAC)
- Different or same power supply lines options for TTC and OBC
- Different power supply line for RTC
- Integrated temperature and current sensors
- Operation temperature -40 ºC to +85 ºC

2.2. Block Diagram

2.2.1. TRISKEL OBC-TTC Block Diagram

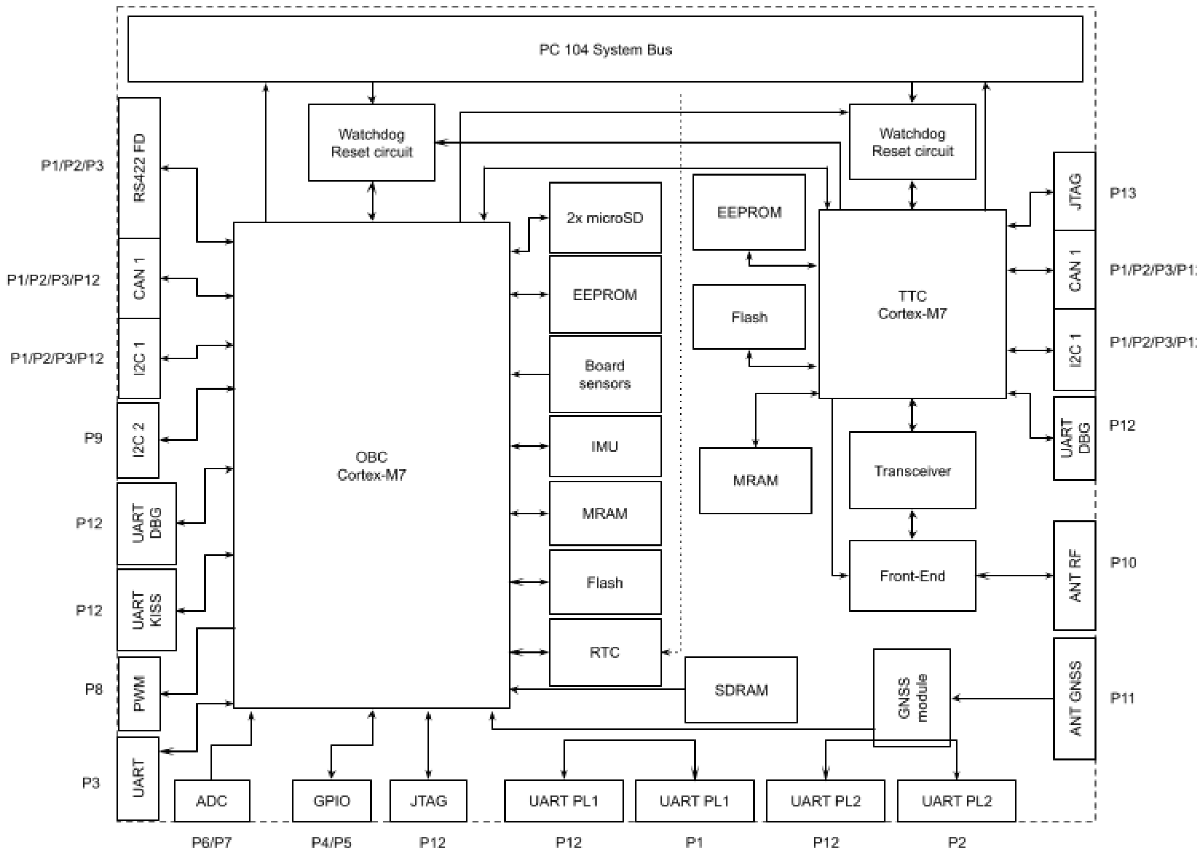

Figure 1: TRISKEL OBC-TTC block diagram.

3. Functional Description

3.1. System Bus

The system bus is the connector that allows stacking TRISKEL on the satellite platform, according to the PC104 Space standard. Through the system bus, TRISKEL receives a power supply (3.3 V) and has means of communications such as CAN and I2C.

3.2. OBC

3.2.1. OBC Cortex-M7

The OBC microcontroller is based on a Cortex-M7 architecture and it runs the on-board software (OBSW) that controls and manages the entire satellite. This microcontroller can be programmable by the user, Alen Space will provide a SDK for the development of the OBSW.

For users who require or desire, Alen Space can provide as an option a complete OBSW compatible with the ECSS PUS standard.

- Arm® 32-bit Cortex®-M7 CPU with FPU
- Up to 280 MHz
- 2 Mbyte Flash
- 1.4 Mbyte of SRAM

3.2.2. Watchdog and Reset Circuit

The TRISKEL OBC block is able to reset itself in case of an anomaly detection. To achieve this, a dedicated reset pin in the OBC-Cortex-M7 is connected to the reset system that disconnects the power chain leaving the OBC completely unpowered for a short time, enough for resetting the component.

The TRISKEL OBC can be reset via the TTC directly, with a specific command from the ground station.

3.2.3. Board sensors

TRISKEL has the capability to measure internal telemetries as currents, voltages and temperatures of different components to detect anomalies.

3.2.4. IMU

An IMU (Inertial Measurement Unit) is included and connected to the OBC for attitude determination.

3.2.5. SDRAM

A high-speed SDRAM (Dynamic Random-Access Memory) of 256 Mb used as main memory for code execution.

3.2.6. MRAM

A persistent memory of 4 Mb for OBSW is included in TRISKEL for critical data storage such as OBSW status. In addition, the MRAM is SEU and SEL Immune technology (NASA NEPP - MRAM Technology Status Report)

3.2.7. NAND Flash memory

The NAND Flash memory stores different kinds of data. The software provides a filesystem.

3.2.8. RTC

TRISKEL includes a Real-Time Clock. It can be connected to a different power supply line that is always ON. This line is the non switchable 3.3 V line of the System Bus.

3.2.9. 3-PWM bidirectional output

TRISKEL provides a connector with 3 outputs to control 3 different magnetic pairs. The control of each magnetorquer is from a pair of bidirectional PWMs from an H-bridge driver.

3.2.10. GPIOs

TRISKEL has 2 connectors with 4 General Purpose Input/Output (GPIO) for different purposes configured by the user. Also, one SPI can be configured as an alternative function.

There are 7 GPIOs included in the System bus. These GPIOs can be optionally disconnected from the system bus by selecting it on the option sheet.

3.2.11. SD Cards

TRISKEL has the capability to use up to 2 microSD cards for massive storage. Each of them can be up to 64 GB.

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3.3. TTC

The TRISKEL-TTC part of the complete subsystem is a half-duplex transceiver specifically for nanosatellites. The radio module supports full in-orbit configuration of some parameters (see User Manual). The medium access is based on a CSMA/CA (collision avoidance) hearing the channel before transmitting to avoid the collisions. The RX/TX switching provides a single port for antenna connection.

3.3.1. TTC Cortex-M7

The TTC microcontroller is based on a Cortex-M7 architecture and it manages the transceiver module. This microcontroller is programmed by Alen Space and it is ready to be used without further action from the user.

3.3.2. Watchdog and Reset Circuit

The TRISKEL OBC block is able to reset the TTC block in case an anomaly is detected. To implement it, a dedicated reset pin in the OBC-Cortex-M7 is connected to the reset system that disconnects the power chain leaving the TTC completely unpowered for a short time, enough for resetting the TTC.

It is also possible to reset the TTC from the OBC.

3.3.3. Transceiver

Connected to the TTC microcontroller, this module implements the radio interface with transmission and reception capabilities. Both uplink and downlink are in the same frequency band, and there is a single transmission and reception port. The communication is half-duplex.

3.3.4. Frontend

The RF frontend connects the transceiver with the antenna. Its objective is to condition the RF signal for both transmission and reception. The transmission path includes the power amplifier and filters needed to amplify the RF signal up to 30 dBm. The reception path includes the LNA and filters needed to boost the transceiver sensitivity.

3.4. On-Board Software

The On-Board Software is available in two flavors: SDK (Software Development Kit) and OBSW.

While the purpose of the former is to be used by developers, the latter is a ready-to-use final product. The contents of both are described in the following sections.

3.4.1 SDK

- **Basic drivers:** Provides access to the low level components of the board, such as communication ports (UART, I2C, CAN, SPI), GPIO, PWM, ADC and SD card.
- **External modules management:** Support for hardware modules surrounding the OBC: RS422/RS485, KISS, DBG, PL-x; WD, RTC, IMU; memories: EEPROM, Flash, MRAM and board sensors.
- **Middleware:** FreeRTOS.
- **Other software:** shell console, filesystem over Flash and Cubesat Space Protocol (CSP).

3.4.2 OBSW

Provides TMTC functionality based on services defined in the ECSS-E-ST-70-41C Telemetry and Telecommand Packet Utilization Standard (PUS):

- **Core services:**
  - Request Verification
  - Housekeeping
  - Events
  - Memory management
  - Time management
  - Time Scheduler
  - Forwarding
  - Storage
  - Test
  - Parameter management
  - Request Sequencing
  - File Management
  - Operations
  - Operational Modes
  - Transfer layer
- **Support to third-party subsystems**

3.4.3. Integration with Alén Space Data Handling Solution

The TRISKEL On-Board Software integrates seamlessly with the Alén Space TOTEM SDR to provide ready-to-fly payloads and high data rates (DVB-S2) transmission with dedicated TOTEM SDR payload functions.

On the ground segment, the Alén Space Mission Control Software (MCS) integration allows a rapid deployment of the CubeSat mission and handles all the data chain from the ground to the satellite.

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4. Connectors

4.1. Connectors layout

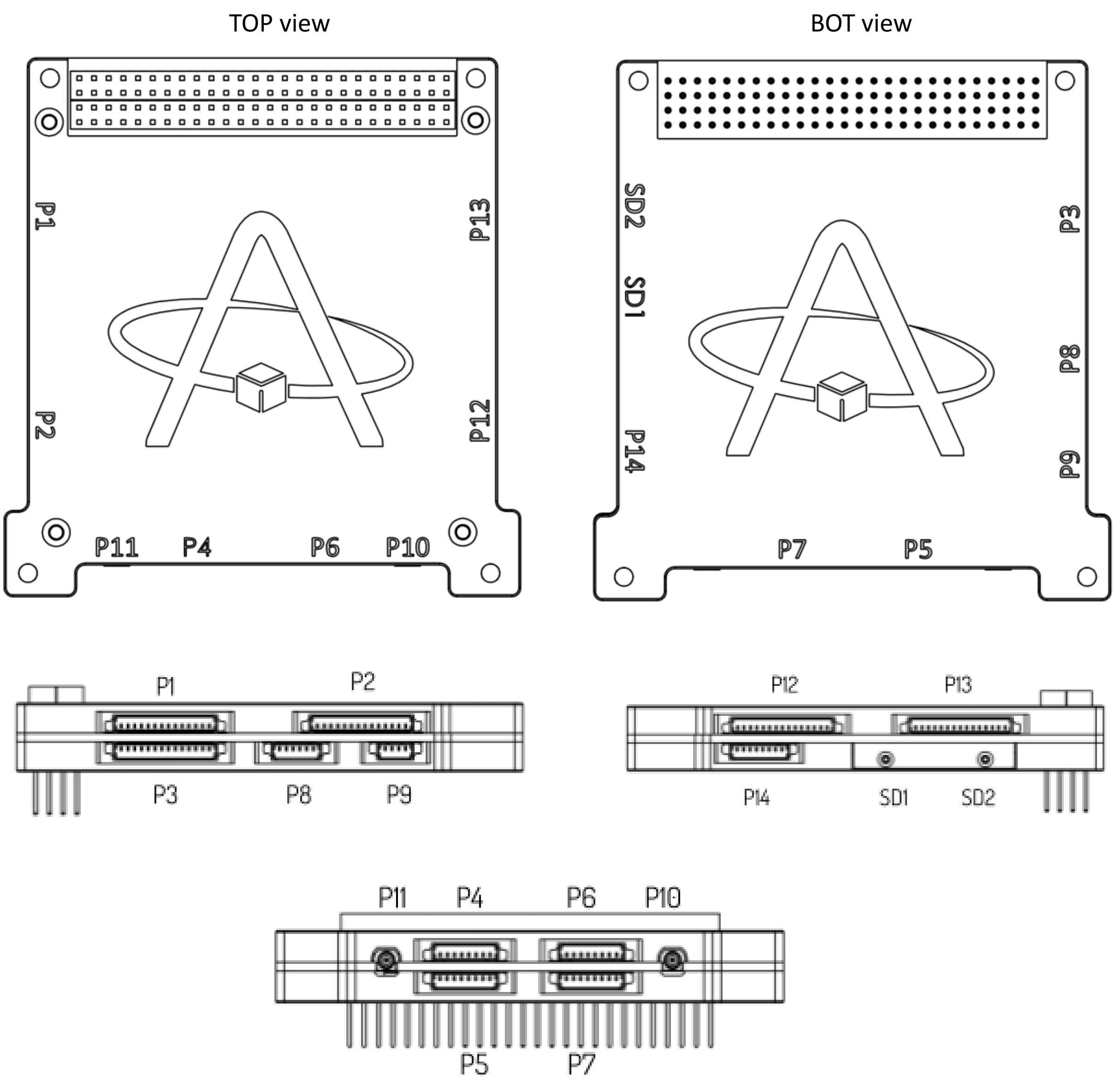

Figure 2:TRISKEL OBC-TTC connectors layouts.

4.2. Connectors pinout

4.2.1. System Bus

This connector is used to provide access to the satellite platform. It is composed of two 2x26-pin SSQ or ESQ connectors from Samtec (SSQ-126-XX-G-D or ESQ-126-XX-G-D). Other compatible connectors can be selected.

Table 1 - System Bus pinout

H1				H2			
Pin	**Description**	**Pin**	**Description**	**Pin**	**Description**	**Pin**	**Description**
1	CANL_1*	2	PPS*	1	CANL_2*	2	-
3	CANH_1*	4	-	3	CANH_2*	4	-
5	-	6	-	5	-	6	-
7	-	8	-	7	-	8	-
9	-	10	-	9	-	10	-
11	-	12	-	11	-	12	-
13	GPIO13*	14	GPIO14*	13	-	14	-
15	GPIO15*	16	GPIO16*	15	-	16	-
17	-	18	-	17	-	18	3V3*
19	-	20	-	19	3V3*	20	3V3*
21	-	22	-	21	-	22	-
23	-	24	-	23	-	24	-
25	-	26	-	25	-	26	-
27	-	28	-	27	3V3_BUS	28	3V3_BUS
29	-	30	-	29	GND	30	GND
31	-	32	-	31	GND	32	-

33	-	34	-	33	-	34	-
35	-	36	-	35	-	36	-
37	GPIO17*	38	-	37	-	38	-
39	GPIO18*	40	-	39	-	40	-
41	SDA1*	42	-	41	-	42	-
43	SCL1*	44	-	43	-	44	-
45	GPIO19*	46	-	45	-	46	-
47	3V3*	48	3V3*	47	-	48	-
49	3V3*	50	3V3*	49	-	50	-
51	3V3*	52	3V3*	51	-	52	-

*Configured by the user in the option sheet. 2 ports shall be selected: one for OBC and the other for TTC. Both subsystems can be supplied by the same line if desired.

4.2.2. P1 - Payload 1

P1 connector is the main interface with the payload 1 of the satellite. This port provides, to the payload, access to the CAN bus, I2C bus, PPS signal, UART for debugging and RS422 Full Duplex bus.

The connector is a Picoblade 14-pin with part number 53261-1471 from Molex.

Table 2 - P1 pinout

Pin	Name	Description
1	PL1_UART_TXO_1	Payload 1 UART Transmission Output (Connected directly to P13)
2	PL1_UART_RXI_1	Payload 1 UART Reception Input (Connected directly to P13)
3	GND_UART	Ground
4	PPS	PPS signal output
5	PPS_GND	Ground
6	SDA1	I2C bus 1 Data (TBC)
7	SCL1	I2C bus 1 Clock (TBC)

8	GND_I2C1	Ground
9	CANH_1	CAN 1 bus High
10	CANL_1	CAN 1 bus Low
11	PL1_RS422_TX+ PL1_UART_TXO_2	RS422 Full-Duplex mode: Payload 1 RS422 TX+ UART mode: UART Transmission Output (Connected to OBC)
12	PL1_RS422_TX-	RS422 Full-Duplex mode: Payload 1 RS422 TX- UART mode: N/A
13	PL1_RS422_RX-	RS422 Full-Duplex mode: Payload 1 RS422 RX- UART mode: N/A
14	PL1_RS422_RX+ PL1_UART_RXO_2	RS422 Full-Duplex mode: Payload 1 RS422 RX+ UART mode: UART Reception Output (Connected to OBC)

4.2.3. P2 - Payload 2 Connector

P2 connector is the main interface with the payload 2 of the satellite. This port provides, to the payload, access to the CAN bus, I2C bus, PPS signal, UART for debugging and RS485 Full Duplex bus.

The connector is a Picoblade 14-pin with part number 53261-1471 from Molex.

Table 3 - P2 pinout

Pin	Name	Description
1	PL2_UART_TXO_1	Payload 2 UART Transmission Output (Connected directly to P13)
2	PL2_UART_RXI_1	Payload 2 UART Reception input (Connected directly to P13)
3	GND_UART	Ground
4	PPS	PPS signal output
5	PPS_GND	Ground
6	SDA1	I2C bus 1 Data (TBC)
7	SCL1	I2C bus 1 Clock (TBC)

8	GND_I2C1	Ground
9	CANH_1	CAN bus High
10	CANL_1	CAN bus Low
11	PL2_RS422_TX+ PL2_UART_TXO_2	RS422 Full-Duplex mode: Payload 2 RS422 TX+ UART mode: UART Transmission Output (Connected to OBC)
12	PL2_RS422_TX-	RS422 Full-Duplex mode: Payload 2 RS422 TX- UART mode: N/A
13	PL2_RS422_RX-	RS422 Full-Duplex mode: Payload 2 RS422 RX- UART mode: N/A
14	PL2_RS422_RX+ PL2_UART_RXO_2	RS422 Full-Duplex mode: Payload 2 RS422 RX+ UART mode: UART Reception Output (Connected to OBC)

4.2.4. P3 - Payload 3 / GNSS Connector

P3 connector main function depends on the device being connected.

When connected to a payload: this port provides, to the payload, access to the CAN bus, I2C bus, PPS signal and RS485 Full Duplex bus.

When connected to a GNSS: the PPS port is an input, and the clock and positioning information is given by the GNSS module through the UART bus.

The connector is a Picoblade 14-pin with part number 53261-1471 from Molex.

Table 4 - P3 pinout

Pin	Name	Description
1	PL3_UART_TXO	Payload 3 UART Transmission Output (Connected to OBC)
2	PL3_UART_RXI	Payload 3 UART Reception input (Connected to OBC)
3	PL3_UART	Ground
4	PPS	PPS signal input(external GNSS)/output (Payload 3)
5	PPS_GND	Ground

6	SDA1	I2C bus 1 Data
7	SCL1	I2C bus 1 Clock
8	GND_I2C1	Ground
9	CANH_1	CAN bus High
10	CANL_1	CAN bus Low
11	PL3_RS422_TX+ PL3_UART_TXO_2	RS422 Full-Duplex mode: Payload 3 RS422 TX+ UART mode: UART Transmission Output (Connected to OBC)
12	PL3_RS422_TX-	RS422 Full-Duplex mode: Payload 3 RS422 TX- UART mode: N/A
13	PL3_RS422_RX-	RS422 Full-Duplex mode: Payload 3 RS422 RX- UART mode: N/A
14	PL3_RS422_RX+ PL3_UART_RXO_2	RS422 Full-Duplex mode: Payload 3 RS422 RX+ UART mode: UART Reception Output (Connected to OBC)

4.2.5. P4 & P5 - GPIOs 1 and 2

P4 and P5 ports contain 4 GPIOs each that can be used by the OBC according to user configuration. Each connector is a Picoblade 8-pin with part number 53261-0871 from Molex.

Table 5 - P4 pinout

Pin	Name	Description
1	GPIO1	General Purpose Input Output 1
2	GND_GPIO1	Ground
3	GPIO2	General Purpose Input Output 2
4	GND_GPIO2	Ground
5	GPIO3	General Purpose Input Output 3
6	GND_GPIO3	Ground

7	GPIO4	General Purpose Input Output 4
8	GND_GPIO4	Ground

Table 6 - P5 pinout

Pin	Name	Description
1	GPIO5 SPI MISO	GPIO - General Purpose Input Output 5 SPI - Master Input Slave Output
2	GND_GPIO5	Ground
3	GPIO6 SPI MOSI	GPIO - General Purpose Input Output 6 SPI - Master Output Slave Input
4	GND_GPIO6	Ground
5	GPIO7 SPI SCK	GPIO - General Purpose Input Output 7 SPI - Clock
6	GND_GPIO7	Ground
7	GPIO8 SPI - SPI CS	GPIO - General Purpose Input Output 8 SPI - Chip Select
8	GND_GPIO8	Ground

4.2.6. P6 & P7 - ADCs 1 and 2

P6 and P7 ports contain 4 ADCs each that can be used by the OBC according to user configuration. Each connector is a Picoblade 8-pin with part number 53261-0871 from Molex.

Table 7 - P6 pinout

Pin	Name	Description
1	ADC1	Analog Digital Converter 1
2	GND_ADC1	Ground

3	ADC2	Analog Digital Converter 2
4	GND_ADC2	Ground
5	ADC3	Analog Digital Converter 3
6	GND_ADC3	Ground
7	ADC4	Analog Digital Converter 4
8	GND_ADC4	Ground

Table 8 - P7 pinout

Pin	Name	Description
1	ADC5	Analog Digital Converter 5
2	GND_ADC5	Ground
3	ADC6	Analog Digital Converter 6
4	GND_ADC6	Ground
5	ADC7	Analog Digital Converter 7
6	GND_ADC7	Ground
7	ADC8	Analog Digital Converter 8
8	GND_ADC8	Ground

4.2.7. P8 - Bidirectional PWM

P8 connector contains 3 PWM signals to be used by the OBC according to user configuration. The connector is a Picoblade 6-pin with part number 53261-0671 from Molex.

Table 9 - P8 pinout

Pin	Name	Description
1	OUT X A	PWM OUT X Forward

2	OUT X B	PWM OUT X Reverse
3	OUT Y A	PWM OUT Y Forward
4	OUT Y B	PWM OUT Y Reverse
5	OUT Z A	PWM OUT Z Forward
6	OUT Z B	PWM OUT Z Reverse

4.2.8. P9 – Auxiliary I2C connector

P9 connector main function is to communicate through an independent I2C bus for different purposes. The final purpose of this port is user configurable.

The connector is a Picoblade 4-pin with part number 53261-0471 from Molex.

Table 10 - P9 pinout

Pin	Name	Description
1	GND	Ground
2	VCC	Power supply (3.3V)
3	SDA2	I2C bus 2 Data
4	SCL2	I2C bus 2 Clock

4.2.9. P10 – ANT RF connector

P10 connector is a RF connector MCX.

Table 11 - P10 pinout

Pin	Description
1	ANT RF signal. Transmission and reception
2	Ground

4.2.11. P12 and P13 - Umbilical and OBC programming connector

P12 and P13 are the umbilical connectors for the satellite.

P12 port contains JTAG for OBC programming, 4 GPIOs, CAN bus and CAN bus

P13 contains all the UARTs. OBC UART for debugging, generic OBC UART, TTC UART for debugging, and 2 UARTs connected directly to payload 1 and payload 2.

Both connectors are Picoblade 15-pin with part number 53261-1571 from Molex

Table 12 - P12 pinout

Pin	Name	Description
1	VREF_JTAG	Voltage reference provided by TRISKEL
2	TRST_JTAG	OBC JTAG Reset
3	TDI_JTAG	OBC JTAG Test Data In
4	TMS_JTAG	OBC JTAG Test mode select
5	TCLK_JTAG	OBC JTAG Test Clock
6	TDO_JTAG	OBC JTAG Test Data Out
7	NRST	Microcontroller reset
8	GPIO9	General Purpose Input Output 9
9	GPIO10	General Purpose Input Output 10
10	GPIO11	General Purpose Input Output 11
11	GPIO12	General Purpose Input Output 12
12	GND	Ground
13	CANH_1	CAN bus High
14	CANL_1	CAN bus Low

15	GND	Ground

Table 13 - P13 pinout

Pin	Name	Description
1	UART_TXO_OBC	OBC UART for debugging Transmission Output
2	UART_RXI_OBC	OBC UART for debugging Reception input
3	GND	Ground
4	UART_TXO_TTC	TTC UART for debugging Transmission Output
5	UART_RXI_TTC	TTC UART for debugging Reception input
6	GND	Ground
7	UART_TXO_AUX	OBC UART for multiple purpose Transmission Output
8	UART_RXI_AUX	OBC UART for multiple purpose Reception input
9	GND	Ground
10	UART_TXO_PL1	Payload 1 UART for debugging Transmission Output
11	UART_RXI_PL1	Payload 1UART for debugging Reception input
12	GND	Ground
13	UART_TXO_PL2	Payload 2 UART for debugging Transmission Output
14	UART_RXI_PL2	Payload 2UART for debugging Reception input
15	GND	Ground

4.2.12. P14 - Internal use

P14 connector is used to program the TTC. **Shall not be used by the customer** (only can be used under the indications of Alen Space).

The connector is a Picoblade 8-pin with part number 53261-0871 from Molex.

5. Data Interface

5.1. CAN bus

The TRISKEL has two CAN Bus interfaces.

The first one routed to the system bus, to all payload connectors, and to umbilical connectors, allowing the communication with the OBC and TTC.

The second one is routed only to the system bus. It can be disabled in the option sheet.

The TTC CAN buses are compatible with CSP (Cubesat Space Protocol) packets.

CSP source code: https://github.com/libcsp/libcsp

5.2. UART

Different UARTs interfaces are available for different purposes. The different UARTs are:

- UART OBC: routed from OBC to umbilical connector (P12). This bus is intended for debugging the OBC through a console.

- UART AUX: routed from OBC to umbilical connector (P12). It allows a non defined communication with the OBC. If the OBSW selected is Alen Space one, this interface is used with CSP over KISS.

- UART TTC: router from TTC to umbilical connector (P12). This is used for debugging the TTC through a console.

- UART PL1: routed from payload 1 connector (P1) to umbilical connector (P12). The objective of this UART is defined by the payload. TRISKEL only gives the option to the payload to have this port available in the umbilical connector.

- UART PL2: same as UART PL1.

- UART PL3: routed from OBC to Payload 3 Connector (P3). When an external GNSS module is used, this bus provides the positioning and timing information to the OBC. If an internal GNSS module is included, this UART is disabled.

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5.3. I2C bus

There are 2 different and independent I2C buses.

- The I2C 1 bus is connected through the System bus and payload connectors to the platform. This bus allows communication with the OBC and TTC.
  The TTC CAN bus is compatible with CSP (Cubesat Space Protocol) packets. (TBC)

- The I2C 2 bus is intended for use with external interfaces from the OBC. Bidirectional ADCs and PWMs are connected to this bus. What's more this bus is available in the P9 connector for other external sensors.

- The I2C 3 bus is only used for internal communication, through OBC and internal sensors. User has no access to this bus

5.4. RS422 Full Duplex

High data rate bus. There are three, each one connected to each payload connector. There is the possibility to use them as RS422 full duplex or even as TTL UART. These options shall be specified in the option sheet.

5.5. JTAG

The JTAG interface is accessible from the umbilical connector and can be used to update the OBSW, even if the satellite is completely integrated.

5.6. SPI

The GPIOs included in the P5 connector can alternatively be configured as SPI bus. This can be configured by software in the OBSW of the OBC microcontroller.

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6. General characteristics

6.1. Power supply

Table 14 -OBC Electrical characteristics

Symbol	Description	Min	Typ	Max	Unit
V_{cc_obc}	Supply voltage	3.15	3.3	3.45	V
I_{cc_obc}	Supply current	-	85	1700	mA

Table 15 -TTC Electrical characteristics

Symbol	Description	Min	Typ	Max	Unit
V_{cc_ttc}	Supply voltage	3.15	3.3	3.45	V
$I_{cc\_ttc\_idle}$	Supply current (Idle)	-	85	285	mA
$I_{cc\_ttc\_rx}$	Supply current (RX)	-	100	300	mA
$I_{cc\_ttc\_tx}$	Supply current (TX, P_{out} = 30dBm)	-	1100	1700	mA

Note: To obtain the total power consumption of the Triskel device, the power consumption of OBC module and TTC module must be added.

6.2. Buses and other interfaces

Table 16 - Buses characteristics

Symbol	Description	Min	Typ	Max	Unit
CAN bus	Bit rate Voltages	 0.5		1000 3.3	kbps V
I2C	Bit rate Voltages	100 0	400	400 3.3	kbps V
RS 422/485	Bit rate	-	-	2	Mbps

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	Voltages	2		6	V
UART_OBC	Bit rate Voltages	- 0	115.2 -	- 3.3	kbps V
UART_AUX	Bit rate Voltages	- 0	- -	1 3.3	Mbps V
UART_TTC	Bit rate Voltages	- 0	115.2 -	- 3.3	kbps V

Table 17 - Generic interfaces characteristics

Symbol	Description	Min	Typ	Max	Unit
GPIO	Output max low voltage Output min high voltage Input threshold voltages low Input threshold voltages high Sink current Source current	0 2.9 2.3 - - -	- - - - 8 8	0.4 3.3 - 1 20 20	V V V V mA mA
ADC	Input voltage range Resolution Conversion rate (12-bit resolution)	0 - -	- 24 -	3.3 - 1	V bits kSPS
PWM	Frequency Current	- -	- -	250 1000	kHz mA

6.3. TTC characteristics

Table 18 - TTC characteristics

Symbol	Description	Min	Typ	Max	Unit
P_{out}	Transmission power	24	-	30	dBm
$H2_{out}$	2nd harmonic power	-	-	-10	dBm
$H3_{out}$	3rd harmonic power	-	-	-10	dBm
P_{adj}	Adjacent channel power		TBD		dBm

Fstability	Frequency stability	-	2	2.5	ppm
$Baudrate_{TX}$	Transmission baud rate	500	-	19200	bps
P_{in_max}	Maximum input power	-	-	10	dBm
Sensitivity	Reception sensitivity 1.2 kbps 4.8 kbps 19.2 kbps		 -123 TBD TBD		 dBm dBm dBm
Doppler	Maximum doppler compensation		TBD		kHz
$Baudrate_{RX}$	Reception baud rate	500	-	19200	bps

7. Absolute maximum ratings

Remarks:

- This is a stress rating only; functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied.
- Operating beyond the maximum ratings for extended periods of time may affect product reliability and cause permanent damage.

Table 19 - OBC absolute maximum ratings

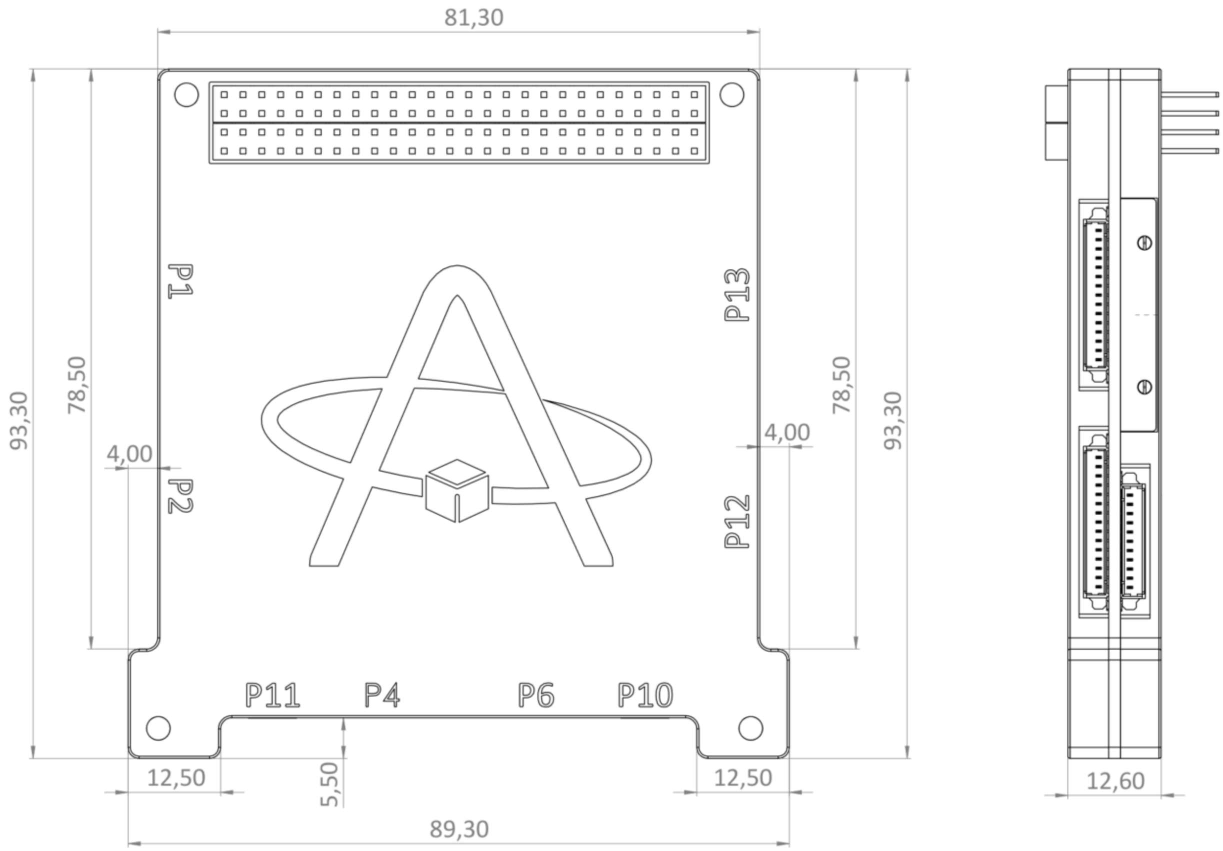
Symbol	Description	Min	Max	Unit
Vcc_obc	OBC Supply voltage	-0.5	3.6	V
Icc_obc	OBC Supply current	-	2	A
Vcc_ttc	TTC Supply voltage	-0.5	3.6	V
Icc_ttc	TTC Supply current	-	2	A
Vin_max	Absolute maximum input voltage	-	3.6	V
Temp	Operating Temperature range	-40	+85	ºC
Pmax_ttc	Maximum RF input power	-	10	dBm

8. Physical characteristics

Table 20 - Physical characteristics

Magnitude	Value	Unit
Size	93.3 x 89.3 x 12.6	mm
Mass	200 (TBC)	g

8.1. Mechanical drawings



**All measures are in mm*

Figure 3 : Mechanical drawings

Note: Stack bus connector pins height depend on the chosen part number

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