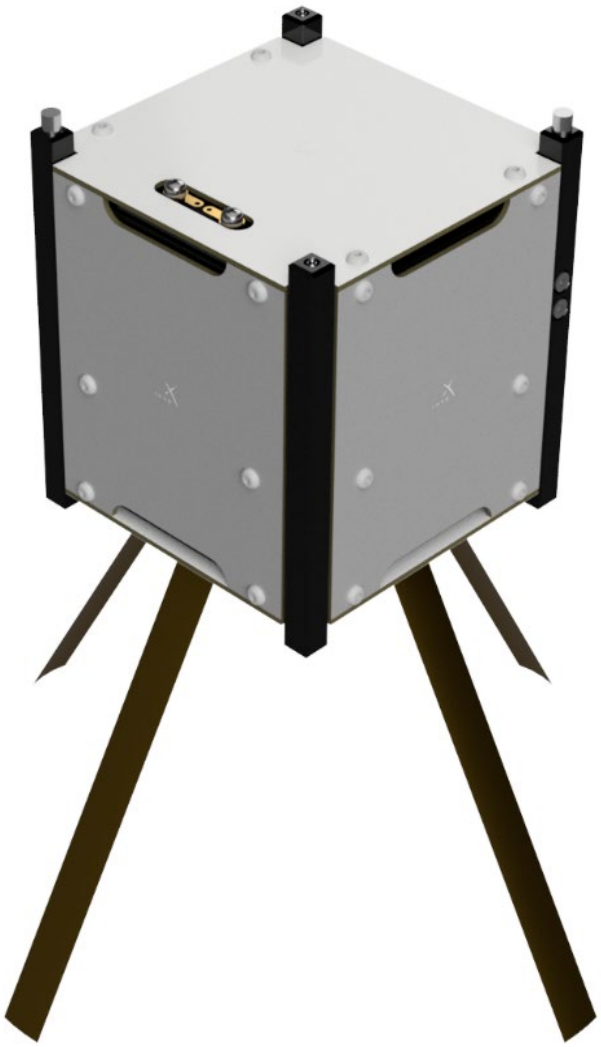
INTERFACE SPECIFICATION



Equipment Description	Cubesat
Ixys Part Number:	118955

Document No.:	118955-ICS-PR-DOC-0001	**Document Name.:**	Interface Specification
Published	**Revision number**	**Revision reason**	**Revised by**
29.04.2024 17.10.2024	0 A	Preliminary Issued for release	SST SST
Prepared		**Checked**	**Approved**
SST		OMH	VHA

TABLE OF CONTENTS

1. INTRODUCTION

1.1. GENERAL NOTES

This document outlines and defines the interfaces of the Ixys Cubesat.

1.2. PURPOSE AND SCOPE

The purpose of this document is to give instructions on how to use and interface with the Cubesat supplied by Ixys AS.

1.3. ABBREVIATIONS

Abbreviation	Description
EPC	Electrical Power Control
IMU	Inertial Measurement Unit
I2C	Inter-Integrated Circuit
JTAG	Joint Test Action Group
NC	Not Connected
PA	Power Amplifier
PC	Personal Computer
PCB	Printed Circuit Board
SPI	Serial Peripheral Interface
SWD	Serial Wire Debug
UART	Universal Asynchronous Receiver-Transmitter
UHF	Ultra-High Frequency
USB	Universal Serial Bus
6DOF	6° of freedom
9DOF	9° of freedom

1.4. SUPPLIER CONTACT INFORMATION

Ixys AS
Langmyra 11
N-4344 Bryne
Norway

+47 51 42 22 22
post@ixys.no
www.ixys.no

2. IXYS CUBESAT

The Ixys Cubesat is a standard 1U size satellite with physical space and electrical interfaces to allow implementing different types of sensor payloads.

The Cubesat contains a stack of an Electrical Power Control PCB, a Communication PCB, and a Turnstile Antenna Feed PCB. The PCBs use the PC-104 mechanical form factor, with M3 size fastening equipment.

The following section 3 describes the PCBs in more detail, section 4 describes firmware functionality and section 5 describes the payload communication interface.

Designator	PART NUMBER	PCB
-A1	119519	Electrical Power Control
-A2	119521	Communication
-A3	119599	Turnstile Antenna Feed

Table 2-1 List of included PCBs

2.1. GETTING STARTED

Once the satellite is received from Ixys AS the first thing to do is to activate the battery pack by opening the side wall PCBs and insert the power connector, this will also uncover the micro-USB connector.

Resetting the satellite fully is done by pressing one of the deployment switches, this disconnects the battery voltage.

3. HARDWARE DESCRIPTION

3.1. CUBESAT

The Cubesat is built as shown in the figure 1 and 2.

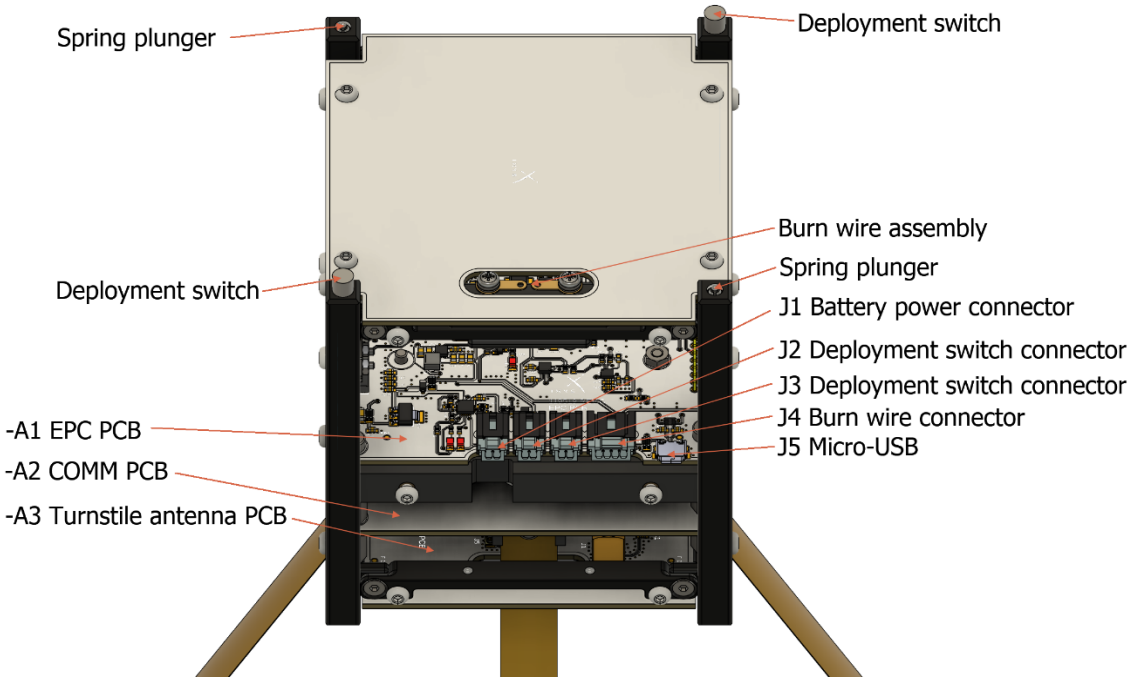


Figure 1 View power connector

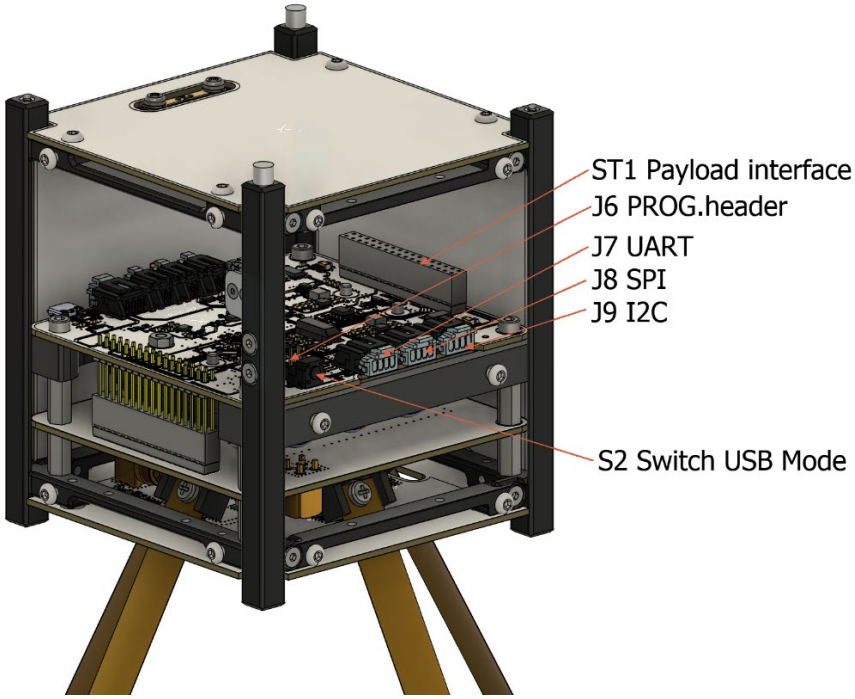


Figure 2 View payload interface

3.2. ELECTRICAL POWER CONTROL PCB

The EPC PCB contains the following components:

- Power supply components (converting battery voltage to 5V and 3.3V)
- Microcontroller (STM32F205)
- Combined 3-axis accelerometer and gyroscope (ISM42670P)
- 3-axis magnetometer (MMC5983)
- Temperature sensor (TC74A0)
- Payload interface circuitry, supporting UART, CAN, SPI and I2C
- 34pin stack connector ST1 Samtec ESQ-117-37-G-D
- J7, J8 & J9 Molex MicroClasp Series 55935-0410

The EPC PCB has a Micro-USB connector to allow configuration and programming, as well as an SWD header to allow microcontroller debugging and flashing.

SPI, UART and I2C payload interfaces are available both in the stack connector ST1 and connectors J7, J8 and J9, while CAN is only available in ST1. The following figure shows the different electrical interfaces available for payload communication.

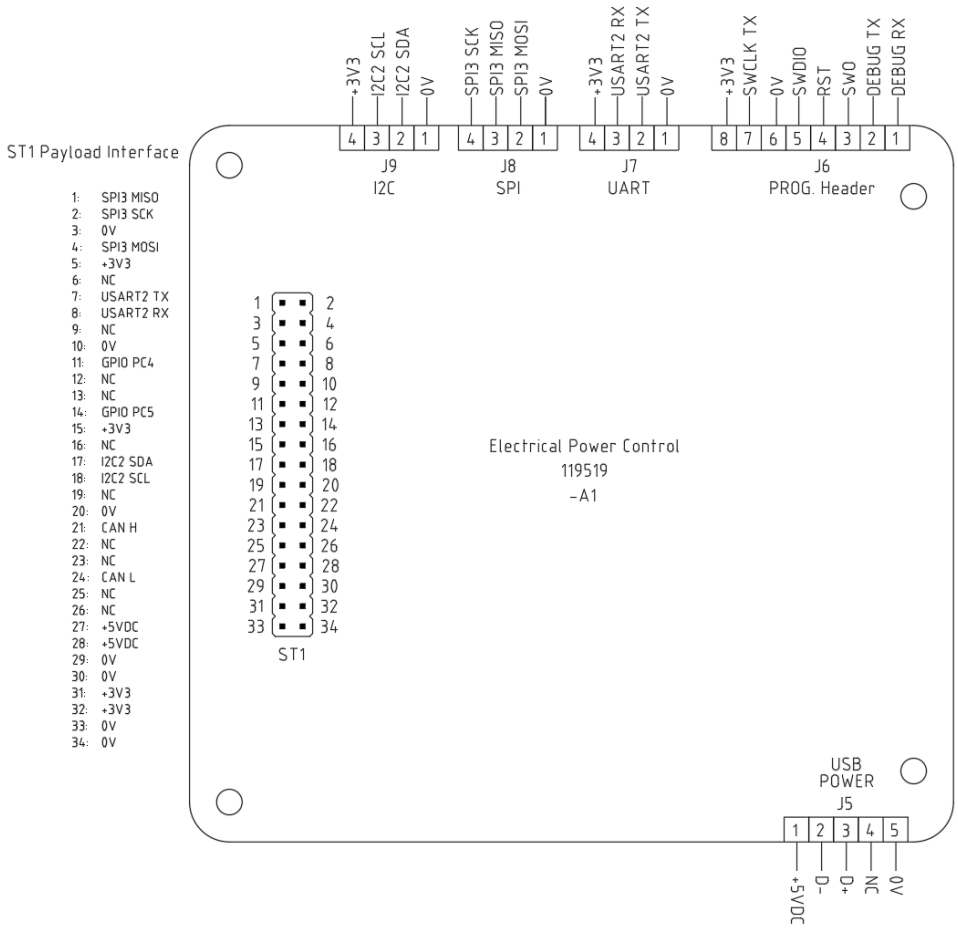


Figure 3 Electrical interfaces available for payload on EPC PCB

3.2.1. ELECTRICAL CONNECTORS

Connector	Pinout	Note
ST1 (Stack connector)	Pin 1: SPI MISO Pin 2: SPI SCK Pin 3: 0V Pin 4: SPI MOSI Pin 5: +3.3V Pin 6: NC Pin 7: UART TX Pin 8: UART RX Pin 9: NC Pin 10: 0V Pin 11: GPIO PC4 Pin 12: NC Pin 13: NC Pin 14: GPIO PC5 Pin 15: +3.3V Pin 16: NC Pin 17: SDA Pin 18: SCL Pin 19: NC Pin 20: 0V Pin 21: CAN High Pin 22: NC Pin 23: NC Pin 24: CAN Low Pin 25: NC Pin 26: NC Pin 27: +5V Pin 28: +5V Pin 29: 0 V Pin 30: 0 V Pin 31: +3.3V Pin 32: +3.3V Pin 33: 0 V Pin 34: 0 V	120 Ω CAN bus termination on PCB. UART, SPI, I2C pins are in parallel to equivalent pins on J7/J8/J9
J5 (Micro USB)	Pin 1: +5V Pin 2: Digital – Pin 3: Digital + Pin 4: NC Pin 5: 0VDC	
J6 (SWD)	Pin 1: Debug RX Pin 2: Debug TX Pin 3: SWO Pin 4: RST Pin 5: SWDIO Pin 6: 0V Pin 7: SWCLK TX Pin 8: +3.3V	
J7 (UART)	Pin 1: 0V Pin 2: TX Pin 3: RX Pin 4: +3.3V	In parallel to equivalent pins on ST1
J8 (SPI)	Pin 1: 0V Pin 2: MOSI Pin 3: MISO Pin 4: SCK	In parallel to equivalent pins on ST1
J9 (I2C)	Pin 1: 0V Pin 2: SDA Pin 3: SCL Pin 4: +3.3V	In parallel to equivalent pins on ST1

Table 3-1 List of connectors and interfaces

3.2.2. POWER

The Cubesat is powered by 3pcs. 18650 Li-Ion batteries wired in parallel. The battery voltage is boosted to +5V, which is then stepped down to 3.3V. The batteries can be charged through the J5 Micro USB connector. The satellite can also be powered directly through this interface.

The PCB contains two separate power supplies, with one powering the satellite itself, and the other being available to the payload through ST1 and J7/J8/J9. The power supply limits are given in the table below.

Voltage	Fuse	Power
+5 V	2A	< 10W
+3.3V	500mA	< 1.65W

Table 3-2 Payload power supply specification

The ST2 stack connector must not be used by the payload.

3.3. CUBESAT COMMUNICATION PCB

Cubesat Communication PCB uses a Texas Instruments CC1120 radio transceiver together with a Guerilla GRF5540 power amplifier. Combined, these gives the satellite the ability to send messages in the UHF range (433 MHz) to the Ixys Ground Station.

Frequency	Signal strength	Power	Bit Rate
433MHz	+31dBm	~1W	1.2 kbps

Table 3-3 Radio Specification

The EPC PCB controls the radio over an internal SPI bus.

3.4. CUBESAT TURNSTILE ANTENNA FEED PCB

The antenna PCB provides a 90° phase shift between four individual ¼ - λ antennas using different RF couplers, providing a circular polarized antenna solution. Matched to 50 Ω impedance.

4. FIRMWARE

The firmware of the EPC PCB has the following functionality:

- Reads all on-boards sensors.
- Controls the radio and communication.
- Provides a configuration interface through USB.

The firmware will toggle LED4 on the EPC PCB continuously while running, as a heartbeat indicator, showing that it is running.

4.1. MODES

The EPC PCB is used both in the ground station and the satellite and, using the shell command “set_ground_station true” or “set_ground_station false” can be used to toggle between them.

In ground station mode, the board will continuously listen for messages from the satellite and dump data from any message received on the shell console.

In satellite mode, the board will turn on the burn wire a given time after power-up, burn the wire for a number of seconds, and then start transmitting messages as per section 4.3.

Note: Both the burn-wire and the radio PA consumes > 1 A, and should hence be used only when powered by battery.

4.2. SENSOR DATA

The EPC PCB integrates the following sensors:

- ICM42670 3-axis combined accelerometer and gyroscope
- MMC5983MA 3-axis magnetometer
- TC74A0 temperature sensor

All sensors are read periodically over an internal I2C bus.

4.3. RADIO COMMUNICATION

Every 5 s, the main microcontroller will build a message to be sent over the radio to the ground station, with following contents:

- Temperature
- 3-axis acceleration
- 3-axis angular acceleration
- 3-axis magnetic field
- Any data received through the payload interface (see section 5)

4.4. CONFIGURATION

When the Micro-USB connector J5 is connected to a computer, it will appear as a serial port. Opening this serial port in a terminal emulator (for instance PuTTY or similar) allows configuration and testing of various aspects of the Cubesat. To view a complete list of commands available, simply write ‘‘help’’.

Selected commands are listed below.

clear	Clear screen
date	Date commands
device	Device commands
get_battery_voltage	Get battery voltage
help	Prints the help message
kernel reboot cold	Reboot
radio	Radio commands
set_ground_station	Set firmware mode to ground station or satellite
version	Show info and version

Table 4-1 Available commands

radio read_register	Read register
radio read_extended_register	Read extended register
radio write_register	Write register
radio write_extended_register	Write extended register
radio get_mode	Get mode
radio get_txbytes	Get number of bytes remaining to be transmitted
radio reset	Reset radio
radio set_pa	Enable antenna power amplifier
radio get_pa	Check antenna power amplifier status

Table 4-2 Radio commands

4.5. PROGRAMMING

If the S2 switch is held while the EPC PCB is powered-on, the microcontroller will boot in USB DFU mode, and hence be programmable over USB, for instance by using STM32CubeProgrammer available from www.st.com.

Alternatively, the microcontroller can be programmed directly with any SWD compatible debug probe (for instance an ST-Link or a Segger J-Link) through the debug connector J5.

5. PAYLOAD COMMUNICATION INTERFACE

Any data received on any of the Payload Communication Interfaces will be included in the radio messages sent from the Cubesat.

Note: The hardware has components for multiple different interfaces, but in the current firmware version only UART is implemented and used.

5.1. UART

The EPC PCB will include any data received over UART in its radio messages. Data can be textual or binary, as desired by the payload implementer.

There is currently no acknowledgement of messages received on the UART interface. Max message length is yet to be determined.

The communication parameters for the UART interface are given in the table below.

Baud rate	9600
Data bits	8
Parity	None
Stop bits	1
Flow control	None

Table 5-1 Payload UART interface parameters

5.2. SPI

Not implemented in current firmware.

5.3. I2C

Not implemented in current firmware.

5.4. CAN

Not implemented in current firmware.

6. ANTENNA BINDING SUGGESTION

It is recommended to use a thin nylon thread to bind up the antennas, for our testing we used 0.2mm. Proper testing with the thread in use must be done. Figure 4 shows the surgeon's knot which is recommended as it is highly durable. Figure 5 shows an image of the antennas bound at our test location.

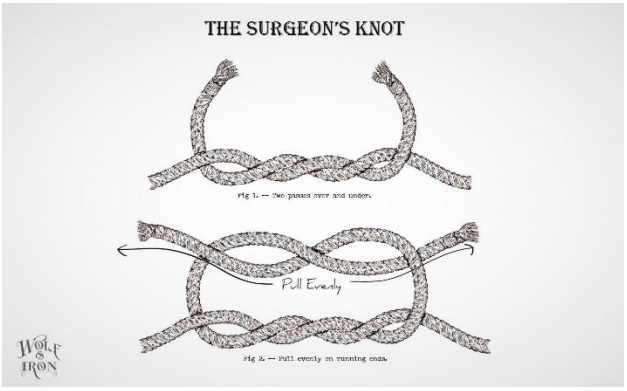


Figure 4 Surgeon's knot

Figure 5 Antennas tied up