

Electronic components: the electronic card

Role

The CubeSat have a telecommunication subsystem that will allow communication between the CubeSat and the ground station to share telemetry data. The primary goal of the communication subsystem is to provide a link to relay data findings and send commands to and from the CubeSat if necessary. Telemetry and command subsystems will ensure communication between the ground station and the CubeSat when both are in range.

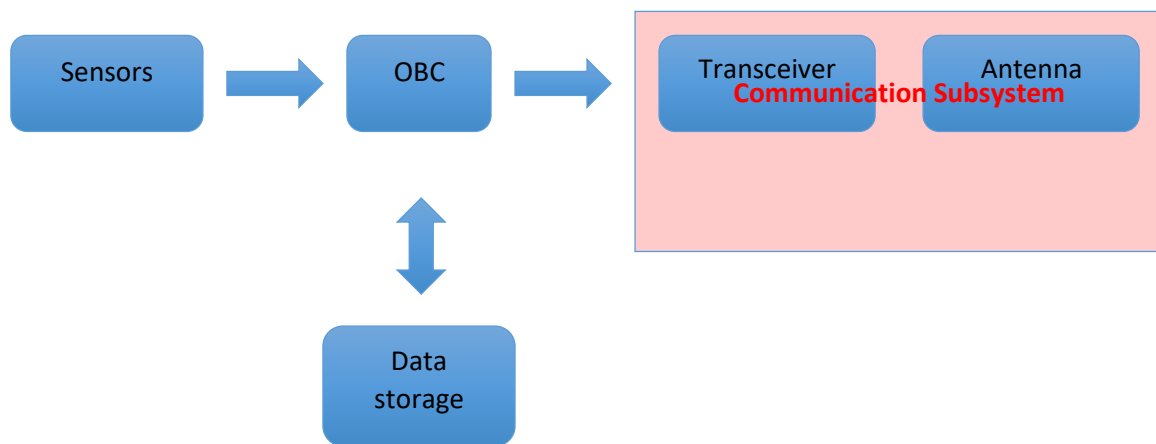


Figure 1: Role of TCS in satellite

The telecommunication subsystem will be composed of a transceiver (which host the emission chain and the reception chain) and an antenna. A transceiver is a single board housing both a transmitter and receiver circuit. The transceiver converts data from the OBC into a form that can be sent to a ground station with a carrier signal. The most common Transceivers for CubeSats operate in both the UHF and VHF bands. This allows the use of the VHF band for downlink and UHF band for uplink.

Constraints:

There are two main constraints.

The first one will be the size and the weight of the CubeSat which is 10 cm³ and 1,33 kg.

The maximum size of the card will be situated under 10x10cm; we can delimit it with the standard PC104 (9.0 cm x 9.6 cm).

About the weight of the card, it must be as little as possible to be sure that the CubeSat will not exceed the limit of 1,33 kg. We can make a first estimation of the constraint at 100g.

The maximum consumption of the CubeSat communication sub-system is 1,5W. This consumption will be effective during a short time, because the OBC will be able shutdown or not the transmission of data for various reasons (such as the ground station not in range anymore, no data to transmit or entering in power saving mode)

The second one will be link to the space environment. For each parameter listed below the card must be able to support them.

- Altitude: 400 – 1000 km above the sea level
- Inclination: 0° to 56° (inclination of ISS)
- Temperature: -40°C to + 80°C
- Radiation: resisting UV radiation, X, protons, and plasma in LEO
- Duration of lifetime: 2 weeks to 1,5 month
- Vibration on the launch

We also need to have in mind the cost of the card, if we can choose a similar card with an important economy for the global budget, it will be preferable.

Furthermore, the band chosen for downlink communications is 435-438 MHz.

Transmission rate: 1200 to 9600 bauds

Existing products

	ISIS TRXUV Full duplex transceiver	Li-1 Radio	He-1 Radio	AMSAT-F
Price	8,500 €	5000 \$	4900 \$	800 €
Weight (g)	75	48 - 52	78	70 - 100
Size (mm)	96x90x15	32x65x10	90x95	90.2x82
Temperature (°C)	[-20;60]	[-30;70]	[-30;70]	[-20;50]
Power (W), Transmitter On Receiver Only	4.0 < x < 0.480	10 < x < 0.20	16 < x < 0.20	5.78 < x < 0.57
	UHF Transmitter downlink			UHF Transmitter downlink
Frequency range	420 – 450 MHz			435 – 438 MHz
Protocols	AX.25 / HDLC			AX.25 / FX.25
Data rate	Selectable: 1200, 2400, 4800, 9600 bauds			1200 to 9600 bauds
	VHF Receiver uplink			VHF Receiver uplink
Frequency range	140 – 150 MHz			145.80-146.00 MHz
Protocols	AX.25 / HDLC			AX.25 / FX.25
Data rate	1200 baud			1200 to 9600 bauds
Link	https://www.isi.space.nl/product/isis-uhf-downlink-vhf-uplink-full-duplex-transceiver/	http://www.asstrodev.com/public_html2/node/2	http://www.astrodev.com/public_html2/node/20	PDF available on demand.

	CPUT VUTRX Clyde Space CMC	CPUT UTRX Clyde Space	NanoCom AX 100	CPUT S-Band CubeSat Transmitter
Price	8,600 \$	8,600 \$?	8,900 \$
Weight (g)	<90	<90	<24.5	
Size (mm)	96x90	PC104	65 x 40 x 6.5	
Temperature (°C)	[-25;61]	[-25;61]	[-40 ;60]	
Power (W), Transmitter On Receiver Only	4.0 – 10.0 <0.250	Low-power Flash based FPGA		
	UHF Transmitter Downlink	UHF Transmitter		
Frequency range	420 – 450 MHz	420 – 450 MHz		
Protocols	AX.25	AX.25		
Data rate	9600		0.1 kbps to 115.2 kbps	
	VHF Receiver Uplink	UHF Receiver		
Frequency range	130 – 150 MHz	420 – 450 MHz		
Protocols	AX.25	AX.25		
Data rate	1200		0.1 kbps to 115.2 kbps	
Link	https://www.clyde.space/products/14-cput-vutrx	https://www.clyde.space/products/34-cput-utrx	http://gomspace.com/index.php?p=products-ax100	https://www.clyde.space/products/35-cput-sband-cubesat-transmitter

Figure 2: Comparison between several communication cards

Existing products have been chosen in correlation with a document that list all the CubeSat sent in space from 2003 to 2016.

For University CubeSats, mains communications systems use cards listed in the tab.

There are two cards (Li-1 and He-1) that are used for satellite communications.

ISIS TRXUV, CPUT VUTRX are two cards globally equivalent, there is a lot of communications established with those systems in past missions. Especially in the five last years.

All the cards present in this table respect all the characteristics that we need to match. The popularity of the **ISIS TRXUV** encourages us to choose her for the entire simulation test.