TXS S-band Transmitter Datasheet

ISIS.TXS.DS.001, version 1.0

Overview

The ISIS High Data-rate S-band Transmitter is a CubeSat compatible transmitter designed to meet the needs of high data-rate downlinks of up to 4.3 Mbps (usable information bit-rate at CCSDS TM Transfer Frame level). The transmitter can be used for both TT&C or Payload Data downlinks. The S-band transmitter is flexible, implementing CCSDS as data link layer protocol and allowing in-flight configuration of data-rate, modulation scheme, frequency, and RF output power.

Highlighted features

- Operates in the 2200-2290 MHz EESS/SRS/SOS allocation
- CCSDS compliant channel coding ensures compatibility with many off-the-shelf demodulators as well as various groundstation networks
- Compatibility with the following demodulators has been verified:
    - Zodiac CORTEX CRT
    - Teledyne Qubeflex
    - Amergint satTRAC
    - RT Logic / KRATOS quantumGND
    - Antwerp Space Omnisat LT
- Compatibility with the following groundstation networks has been verified:
    - KSAT-lite
- Strong Forward Error Correction (FEC) to maximize link throughput
- No need for data pre-processing: all channel coding is performed inside the transmitter
- Up to 4.3 Mbit/s useful datarate (at CCSDS TM Transfer Frame level)
- In-flight configurable RF parameters (Frequency, data-rate, RF power, FEC parameters) – allows to optimize throughput during a satellite overpass
- Data interfaces: LVDS (payload data), I^2C (housekeeping)
- Safety watchdog
- Adjustable RF output power from 27 to 33 dBm
- Power control loop to keep RF output power constant over varying operating conditions
- IPC-A-610 Class 3 assembly

Key specifications

Table 1 TXS key specifications

Parameter	Value / Description
RF and data link specifications	
Frequency range	2200 – 2290 MHz
Frequency step size	1 kHz
Frequency stability	+/-10 ppm
RF output power	27 to 33 dBm (settable) ± 1 dB
Spurious emissions	Less than -60 dBc
Transmitted data rate (on-air)	up to 10 Mbit/s (5 Msym/s, OQPSK)
Useful information bitrate	up to 4.3 Mbit/s (at TM transfer frame level)
Supported symbol rates	0.625, 1.25, 2.5, 5 Msym/s selectable
Modulation scheme	Suppressed carrier: BPSK, OQPSK selectable as per CCSDS 401.0-B
Pulse shaping filter	Root raised cosine Nyquist pulseshaping as per CCSDS 413.0-G. Roll-off: 0.35 / 0.5 selectable
Forward Error Correction	Convolutional (K=7, ½) as per CCSDS 131.0-B Reed Solomon (223, 255) as per CCSDS 131.0-B
Pseudorandomization	Pseudorandomization as per CCSDS 131.0-B
Synchronization	32 bit Attached Sync Marker as per CCSDS 131.0-B
Power specifications	
Power consumption	13 W (for 33 dBm RF output power)
DC supply voltage	7 to 20 V
Interfaces	
Payload data interface	LVDS
Housekeeping data interface	I^2C
Mechanical specifications	
Dimensions	98.8 x 93.3 x 14.5 mm
Mass	132 g
Environmental specifications	
Operating temperature	-40 to +70 °C

Electrical characteristics

Table 2 Electrical Characteristics

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Power supply						
DC supply voltage	V_{cc}		7		20	V
DC power consumption	P_{DC}	Mode: Supervisor on		0.08	0.1	W
DC power consumption	P_{DC}	Mode: TX standby		1.5	1.6	W
DC power consumption at rated output power	P_{DC}	Mode: TX on P_{RF} = 33 dBm, Vcc = 16.0 V		13	14	W
RF						
RF output power	P_{RF}	f_{TX} = 2245 MHz, Vcc = 16.0 V	30	33	35	dBm
RF output power stability	ΔP_{RF_T}	-25° C ≤ T_{amb} ≤ 55 ° C		1	2	dB
RF output power stability	ΔP_{RF_f}	2200 MHz ≤ f_{TX} ≤ 2290 MHz		1.5	2	dB
Spurious suppression	N/A	P_{RF} = 33 dBm			-60	dBc
Transmit center frequency	f_{TX}		2200		2290	MHz
Frequency stability	Δf				±10	ppm
I²C interface[1, 2]						
Bus logic low-level input voltage	V_{IL}		0		1.0	V
Bus logic low-level output voltage	V_{OL}		0.47		0.6	V
Bus logic high-level voltage	V_{OH}		2.3		3.3	V
LVDS Outputs[3]						
Differential output voltage	V_{OD}		250	310	450	mV
Offset voltage	V_{OS}		1.125	1.17	1.375	V
Output high voltage	V_{OH}			1.33	1.6	
Output low voltage	V_{OL}		0.90	1.02		V
LVDS Inputs[4]						
Differential input high threshold	V_{TH}	V_{cm} = 1.2 V, 0.05 V, 2.95 V		-35	0	mV
Differential input low threshold	V_{LH}	V_{cm} = 1.2 V, 0.05 V, 2.95 V	-100	-35		mV
Common-mode voltage range	V_{CMR}	V_{ID} = 200 mV p-p	0.1		2.3	V
Input current	I_{IN}	V_{IN} = 2.8 V	-10	±5	+10	µA
	I_{IN}	V_{IN} = 0 V	-10	±1	+10	µA
LVDS input termination resistance	R_T			100		Ohm

1. I²C repeater IC type: PCA9517A
2. The PCA9517A buffers on the TXS are powered by 3.3 V, therefore a nominal bus logic high voltage of 3.3 V is supported
3. LVDS Receiver IC type: ADN4668
4. LVDS Transmitter IC type: ADN4667

Absolute Maximum Ratings

Stresses at or above the absolute maximum ratings in Table 3 may cause permanent damage to the product. Operation at or beyond the maximum operating ratings may affect product reliability.

Table 3 Absolute Maximum Ratings

Parameter	Symbol	Min	Max	Unit
Supply voltage	Vcc	6	26	V
Operating temperature range	T_{amb}	-40	70	°C
Storage temperature range	$T_{storage}$	-40	85	°C
Voltage on I²C pins	V_{I2C}	-0.5	7	V
I²C pull up resistor value	R_{pu}	1.2		kOhm
LVDS input pin voltage	V_{IN_LVDS}	-0.3	3.6	V
LVDS output pin voltage	V_{OUT_LVDS}	-0.3	3.6	V
GPIO input voltage, any GPIO pin	V_{IN_GPIO}	-0.3	3.6	V

Block diagram

TXS is based on a MicroSemi SmartFusion2 SoC. A separate supervisor MCU takes care of power switching, telemetry gathering and watchdog functionality. An LVDS interface is provided for high speed payload data, although (low speed) data to be transmitted can also be routed via the I²C bus.

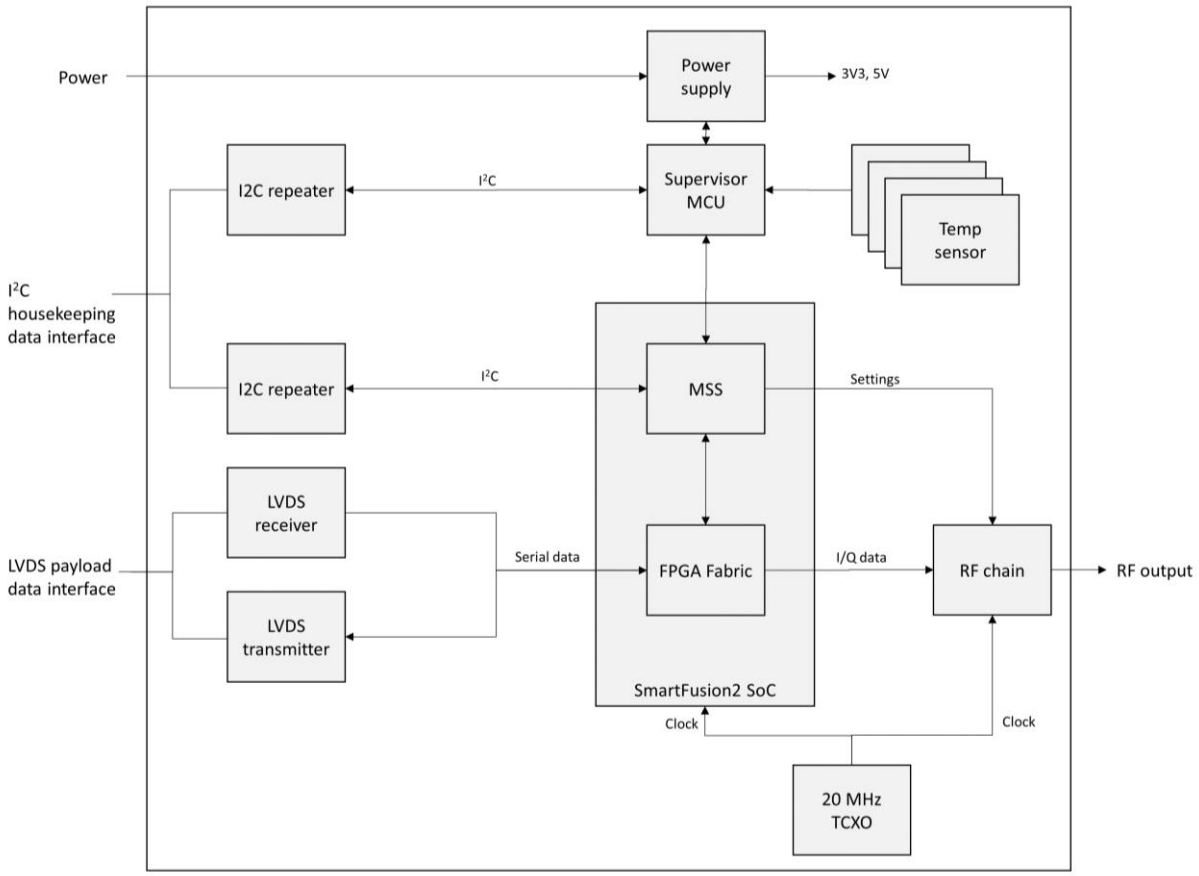

Figure 1 TXS high level block diagram

Typical performance graphs

Conditions: T_{amb} = 25 ° C, V_{cc} = 16.0V unless otherwise stated

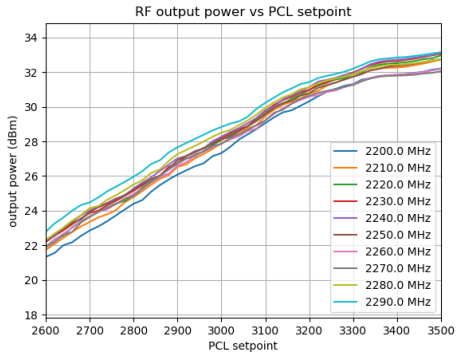

Figure 2 RF output power vs power control loop setpoint for various frequencies (closed loop)

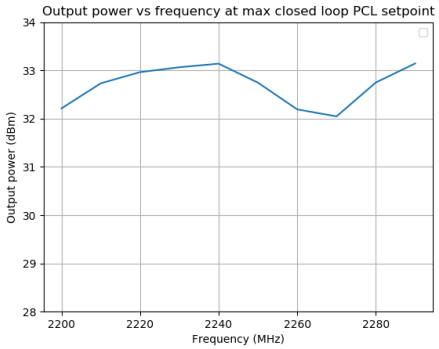

Figure 3 RF output power vs frequency at max closed loop PCL setpoint

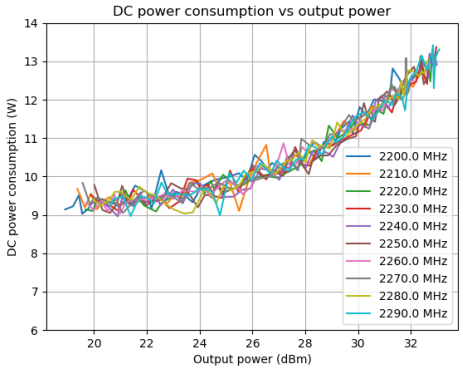

Figure 4 DC power consumption vs RF output power

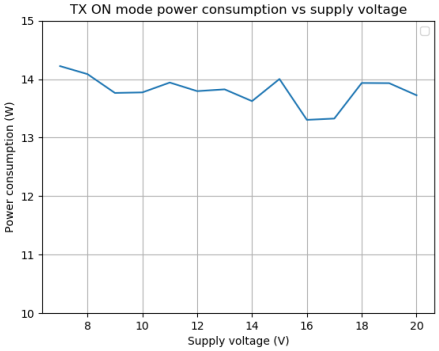

Figure 5 TX ON mode DC power consumption vs supply voltage

Typical link budget

Table 4 provides a typical link budget achieved with TXS to a small groundstation (1.9 m diameter), for a link with these parameters, 2.1 Mbit/s OQPSK can be supported from 5 degrees elevation. With higher groundstation G/T, larger usable datarates can be supported.

Table 4 Typical TXS link budget

Parameter	Value	Unit	Rationale
Frequency	2245.0	MHz	2200-2290 MHz SOS / EESS / SRS space-to-Earth allocation
Satellite transmitter power	3.0	dBW	2W / 33 dBm
Satellite TX losses	1.0	dB	Assumption
Satellite antenna gain	0.0	dBi	Typical patch antenna gain for 5 deg elevation and Nadir pointing satellite
Satellite EIRP	2.0	dBW	
Satellite pointing loss	0.5	dB	Assumption
Orbital altitude	600000.0	m	Typical LEO orbit
Elevation angle	5	deg	Minimum elevation for communication
Range	2329031.4	m	
Path loss	166.8	dB	
Atmospheric losses	0.5	dB	Source: RD3, 99% of the time, Madrid DSN
Ionospheric losses	0.1	dB	Approximate mean values for low earth station elevation angle
Polarization losses	0.0	dB	No polarization mismatch assumed
Earth station pointing loss	1.0	dB	Assumption
Earth station figure of merit	9.0	dB/K	Typical S-band station figure of merit (1.9 m diameter antenna)
Channel symbol rate	2500000.0	sym/s	2.5 Msym/sec
Code rate	0.430502	-	CCSDS RS (255, 223) + conv R = 1/2
Information bitrate	2152510	bit/s	5 Msym/sec OQPSK, RS (255, 223) + conv R = 1/2, interleaving depth = 1
Information bitrate	63.3	dBHz	In dBHz
Implementation loss	2.0	dB	Pessimistic assumption for a typical demodulator
Eb/N0	5.4	dB	
Required Eb/N0	2.4	dB	OQPSK, RS(255, 2223) + C(7, 1/2) for a BER 1E-5
Link margin	**3.0**	dB	

Note: In the above table, losses are denoted by a positive number.

Physical layout

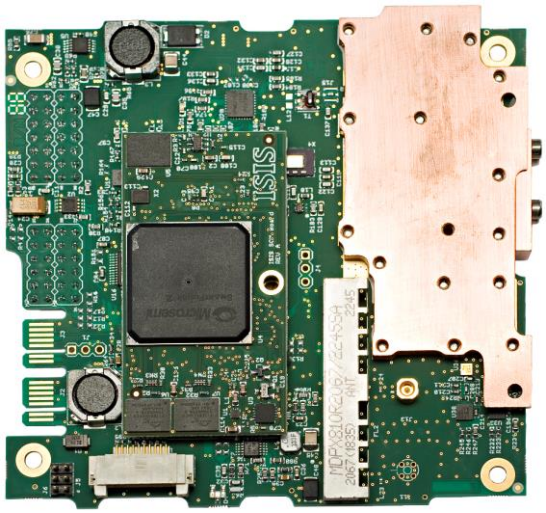

Figure 6 Top view

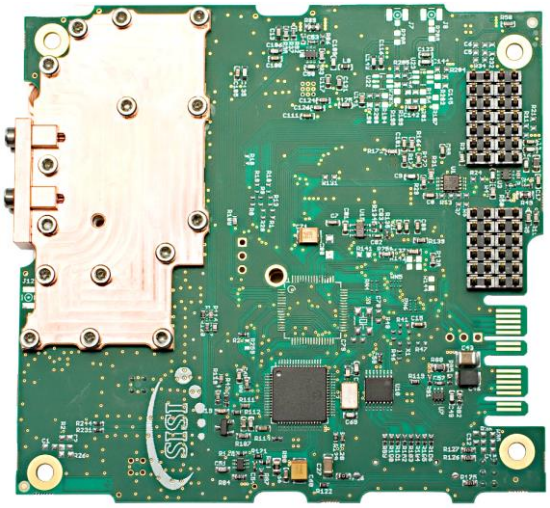

Figure 7 Bottom view

Mechanical outline

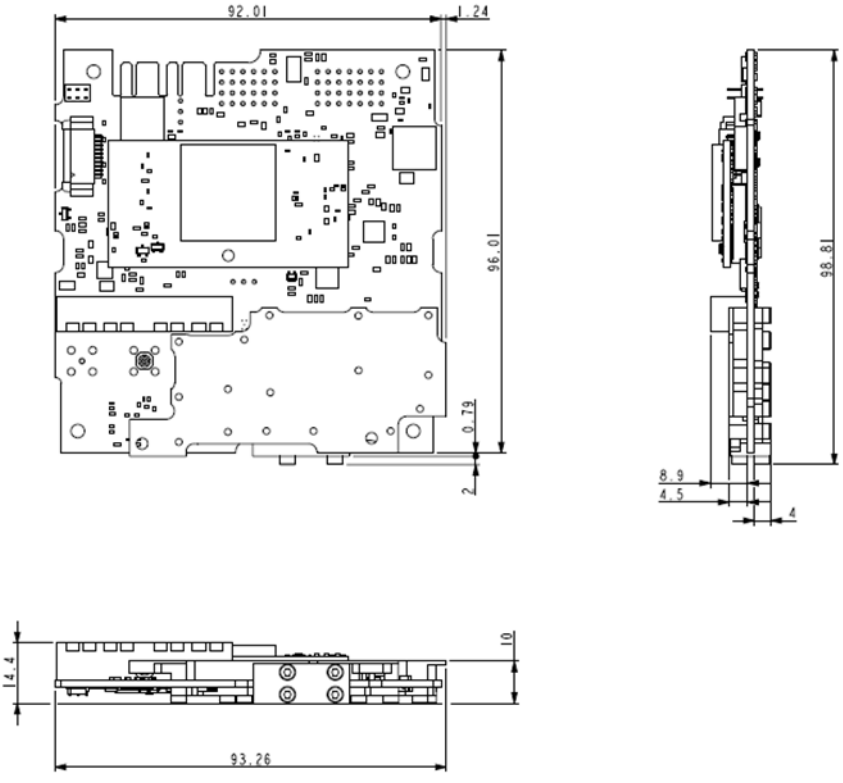

Figure 8 Mechanical outline[1]

[1] This mechanical outline drawing does not contain the CSKB-lite connector, since a number of options for this connector are available. Contact ISIS for details.

Disclaimer

The contents of this document are subject to the relevant provisions in the contract concluded between the parties. ISIS – Innovative Solutions In Space B.V. (“ISIS”) shall not be liable, in full or in part, for any damage arising out from the application or use of any product or circuit described herein, in case such application or use are carried out in a manner not in line with the instructions and warranties provided in the User Manual, Safety Manual, product information sheets or any other document provided by ISIS upon the delivery of the product (“Documents”). Further, ISIS shall not be liable for any damage caused by any use which exceeds the function(s) of the product, or does not conform to such function(s) as described in the Documents. ISIS shall not be liable for any damage arising from a use which is not carried out in a manner conforming to acceptable practices in the aerospace industry.

ISIS warrants that the product is supplied after relevant tests had shown the product is in good order and functioning, as far as these tests may indicate and predict product functionality.