NanoCom Link IS1
Inter Satellite Communication Product

Preliminary Datasheet

Product name: NanoCom Link IS1

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1 Overview

NanoCom Link IS1 is a product for satellite to satellite in-plane communication in S-Band. It uses Time Division Duplex to form a two-way half-duplex inter satellite communication link within the frequency band 2200MHz to 2290MHz, and consists of the following GomSpace devices:

NanoCom Link IS1:

- SDR: NanoCom SDR MK3, equipped with one TR600.
- ANT: NanoCom ANT2150-ISL, S-Band frontend, half duplex RX and TX.
- Inter Satellite Link: S-Band TDD BPSK modulated, proprietary sync and coding at 100Kbit/sec.

Two NanoCom Link IS1 products are needed to form an intersatellite communication system.

Different antenna back plates are available when ordering the product based on an option sheet. The option sheet can be found on the GomSpace web page.

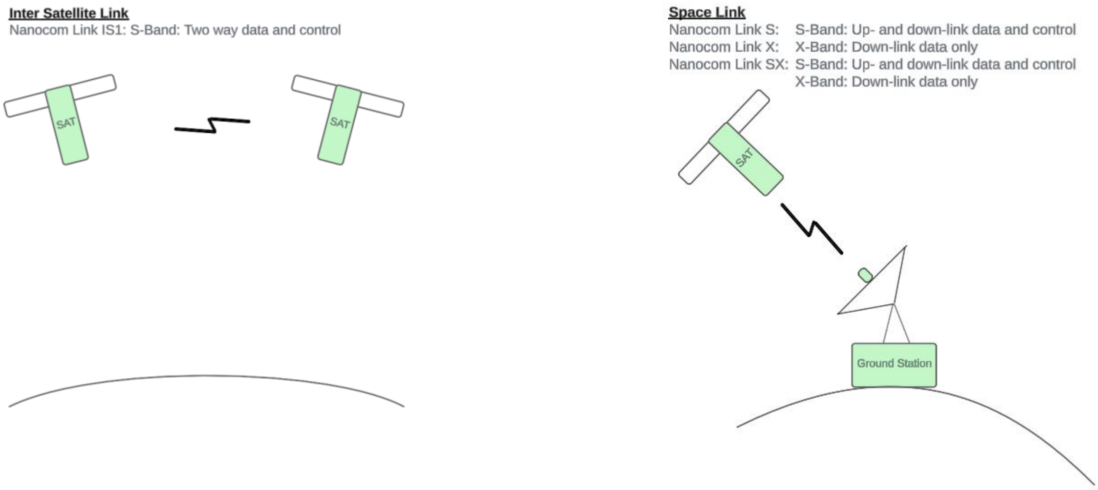


Figure 1-1: Supported configurations by NanoCom Link IS1, S, X and SX.

Figure 1-1 illustrates the Inter Satellite Link and Space Link configurations supported by the NanoCom Link family. Note, Inter Satellite Link and Space Link systems are individual systems which are operating independent of each other. Refer to the NanoCom Link S, X and SX datasheet for further information on Space Link products.

This preliminary datasheet summarizes the key performance characteristics as well as selected parameters relevant for integration and interfacing with the NanoCom Link IS1 product in a satellite. Further details are available in the datasheets for the individual products as well as the *NanoCom Link IS1 User Manual*.

2 System Overview

Inter satellite communication is established between two NanoCom Link IS1 systems using Time Division Duplex.

A single 120kHz wide channel in the frequency band 2200 to 2290MHz is divided into RX and TX time slots. The slots have a combined duration of 333msec. Using BPSK modulation at a rate of 100kB, data is exchanged between the two IS1 systems in turn. A single TX time slot consists of a preamble followed by payload data. The preamble is used by the receiving spacecraft for carrier acquisition. A pulse per second signal synchronized to GNSS time serve as TDD timing reference on each satellite.

Due to regulations on maximum power flux density imposed by the International Telecommunication Union, the achievable communication distance is currently limited to 300KM. This assumes the IS1 antennas on each spacecraft are facing each other and configured for a TX power of 20dBm. It is possible to increase the output power up to 30dBm. In that case ITU regulation on power flux-density is violated but the possible communication distances increase up to 900KM.

Future versions of the IS1 product are planned to increase communication distance beyond 300KM, while fulfilling ITU requirements on PFD. One possibility could be to incorporate Direct Sequence Spread Spectrum. With DSSS it will be possible to fulfil ITU regulations on PFD while transmitting up to 30dBm by spreading the TX power over a larger bandwidth.

Figure 2-1 provides a high-level system overview of the Nanocom Link IS1 product. Refer to the *NanoCom Link IS User Manual* for detailed description on how to configure and control the system.

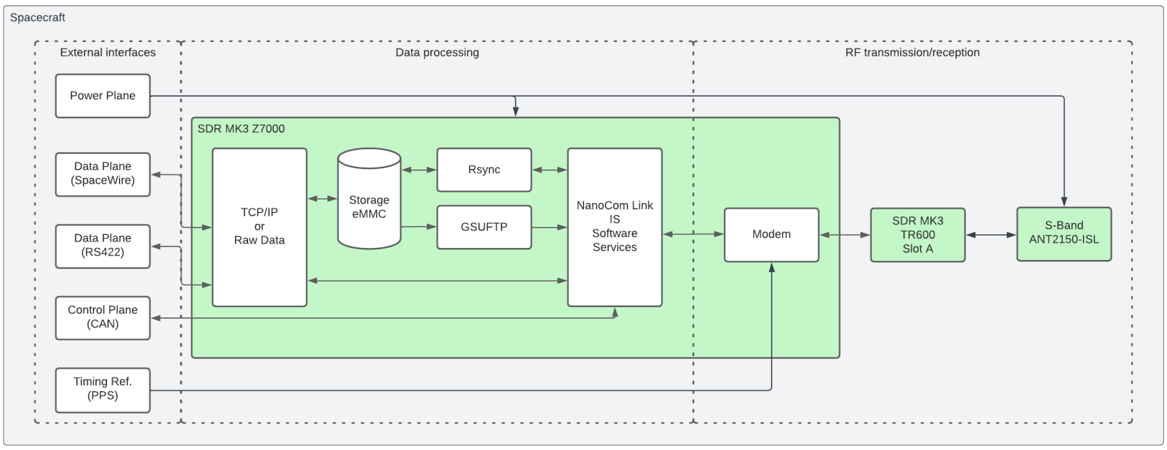


Figure 2-1: High-level system overview.

Power Plane

Power supply for the NanoCom SDR MK3 and NanoCom ANT2150-ISL.

Control Plane

The system is configured and controlled using CubeSat Space Protocol over the CAN interface. Telemetry can be obtained using that interface as well.

Data Plane

The product is equipped with three SpaceWire and one RS422 interface that can be used for data transfer. Data can be transmitted instantaneously or stored for future transmission. The data plane may also be used for control in addition to CAN.

Timing Reference

External Pulse Per Second signal to ensure proper TDD alignment between two IS1 systems.

3 Absolute Maximum Ratings

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the product.

Symbol	Parameter	Min	Max	Unit
$T_{Storage}$	Storage temperature	-40	85	°C
T_{IF-SDR}	SDR thermal interface temperature	-35	53	°C
$T_{IF-ANT2150}$	ANT2150-ISL thermal interface temperature	-35	57	°C
V_{SDR}	SDR MK3 supply voltage	-0.3	36	V
$V_{MAIN-2150}$	ANT2150-ISL main supply voltage	8	18	V
V_{SPW}	SpaceWire / LVDS voltage levels	-0.4	2.6	V
V_{RS422}	RS422 input voltage levels	0	4	V
V_{CAN}	CAN voltage levels	-60	60	V
V_{PPS}	PPS voltage levels	-0.5	4	V
$P_{IN-2150}$	Maximum input power at ANT2150-ISL, 2200 to 2290MHz		-40	dBm

4 External Interfaces

Below is a high-level overview of the NanoCom Link IS1 system solution. The following external interfaces are available for integration with the spacecraft / satellite bus:

Power: Power supply for NanoCom SDR MK3 and NanoCom ANT2150-ISL.

Control: The system is configured and controlled using CubeSat Space Protocol over a CAN interface. Telemetry can be obtained using that interface as well.

Data: 1x RS422 and 3x SpaceWire interfaces are available for TCP/IP or raw data transfer of payload data.

Debug: On ground debug and firmware upgrades are possible using the debug interface. Not intended to be used for flight or to be integrated with the satellite bus. Included for optional debug and test purposes.

PPS: Pulse Per Second LVDS based timing reference for precise time keeping and synchronization between two IS1 systems. A 1Hz signal to be provided by a GPS receiver onboard the spacecraft synchronized to GNSS time.

Future versions of the IS1 product are planned which will support single-ended 3.3V CMOS logic PPS levels in addition to LVDS. The current plan is to use IO1 on PL SE IO-1 connector for single-ended PPS support.

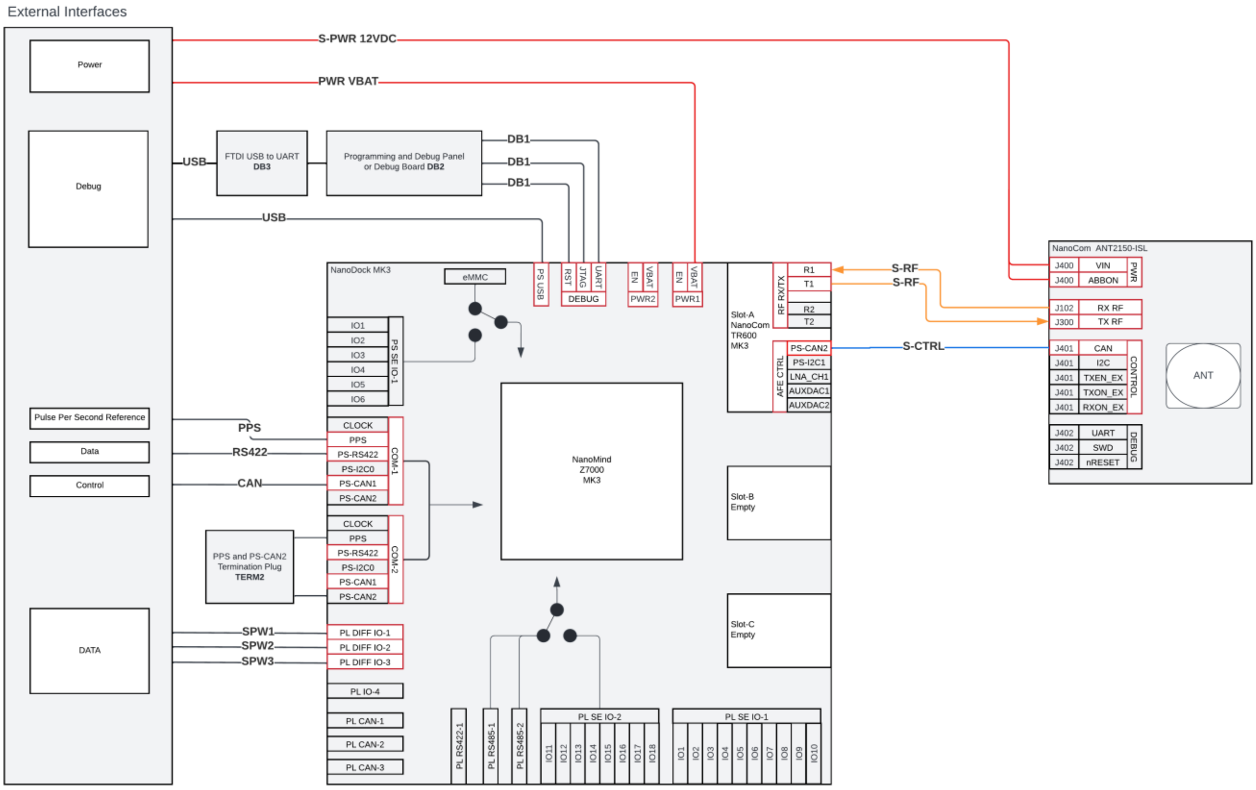


Figure 4-1: NanoCom Link IS1 system overview[1].

Note 1: SDR MK3 and ANT2150-ISL are equipped with different interfaces. It's only a subset of those which are used / supported within the NanoCom Link family. Unused or unsupported connections are greyed out and doesn't carry any external signals in the block diagram.

Cables necessary for interfacing between the SDR MK3 and NanoCom ANT2150-ISL are included with the product. This includes power cables as well. Below is an overview of cables included with the product:

ID	Length	Description
PWR	50cm	SDR MK3 power to flying leads
S-PWR	50cm	ANT2150 power to flying leads
DB1	3.5cm	SDR MK3 debug harness[1]
DB2	N.A.	SDR MK3 debug breakout PCB[1]
DB3	N.A.	FTDI USB-TTL serial cable[1]
USB	100cm	SDR MK3 USB Cable[1]
S-RF	50cm	RG-178 Coax cable, SSMCX to SMPM[3]
S-CTRL	50cm	TR600 MK3 to ANT2150 control harness
TERM2	N.A.	SDR MK3 Mainbus CAN2 and PPS termination[2]

Table 4-1: Product cable kit content.

Note 1: Included for debug / test purpose only.
Note 2: For the NanoCom Link IS1 a CAN and PPS termination resistor is needed on the SDR DOCK. A termination plug is included in the cable kit and can be inserted into either COM-1 or COM-2 on the SDR MK3 DOCK. The plug is equipped with 120ohm PS-CAN2 and 100ohm PPS termination resistors.
Note 3: Minimum bend radius is 10mm.

The location of the required individual connectors is documented in the next section. Followed by a detailed connector pinout for the Power, Control and Data along with the RF interface. These are the only electrical interfaces to be integrated with the spacecraft / satellite bus.

4.1 Interface Connectors

Interface connectors used by NanoCom Link IS1 on NanoCom Link SDR MK3 and ANT2150-ISL.

4.1.1 NanoCom SDR MK3

The SDR MK3 is equipped with one TR-600 in Slot A for NanoCom Link IS1 operation, Slot B and C are empty. A perspective view of Slot A configuration is shown below.

Figure 4-2: Perspective view of SDR MK3 configured for NanoCom Link IS1 operation.

All external connectors reside on the dock except for the interface for the active frontend ANT2150-ISL, which are located on TR600. The individual connector placement is illustrated below.

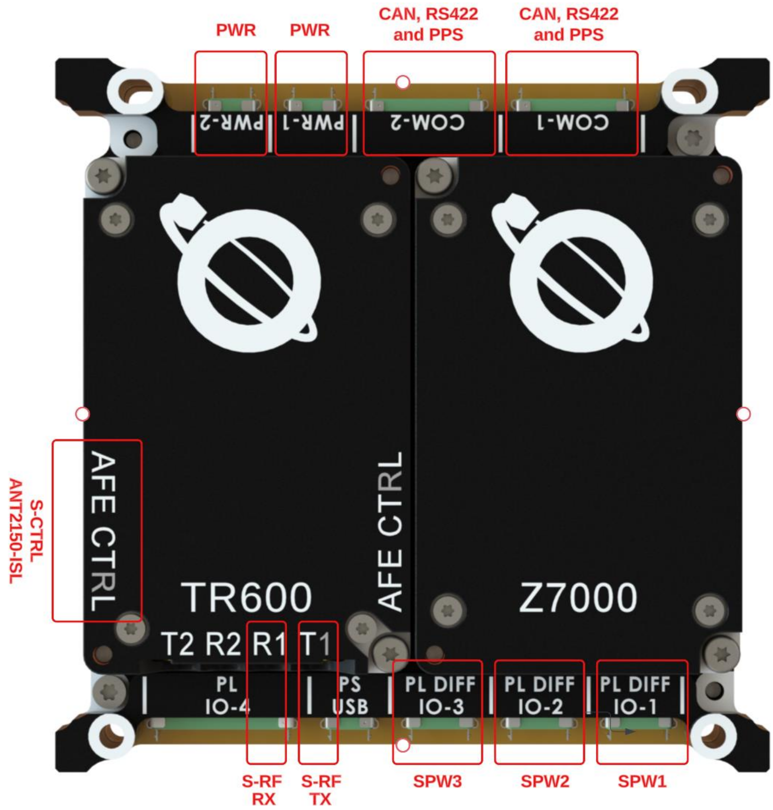


Figure 4-3: SDR MK3 NanoCom Link IS1 top view.

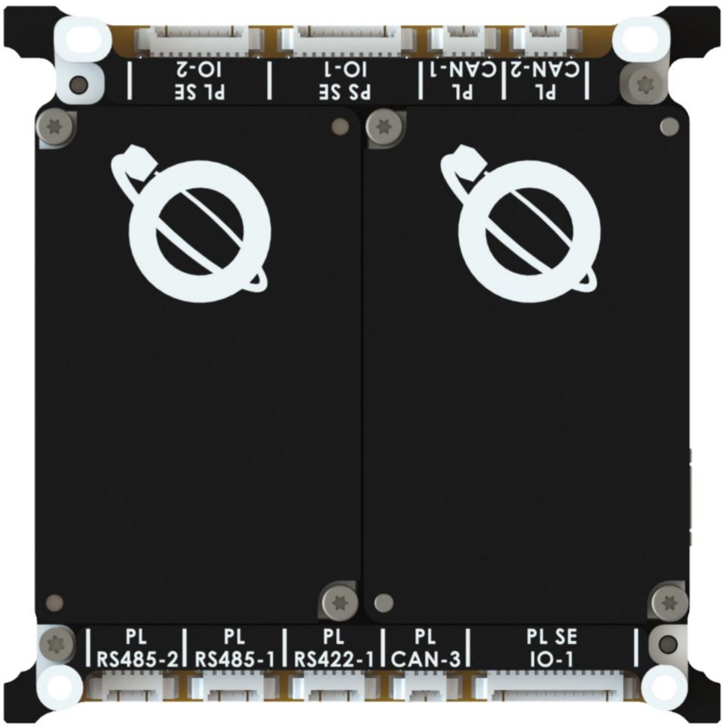


Figure 4-4: SDR MK3 NanoCom Link IS1 bottom view.

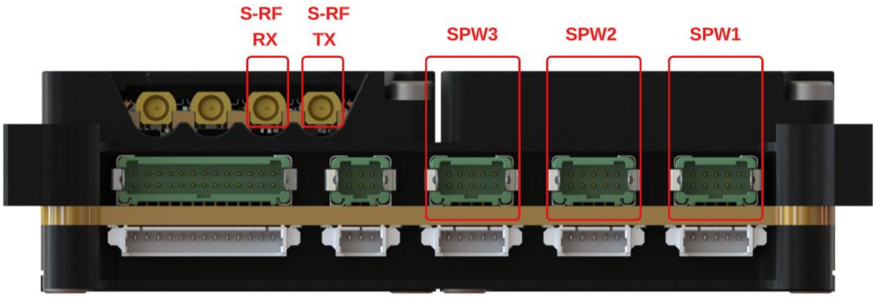


Figure 4-5: SDR MK3 NanoCom Link IS1 front side view.

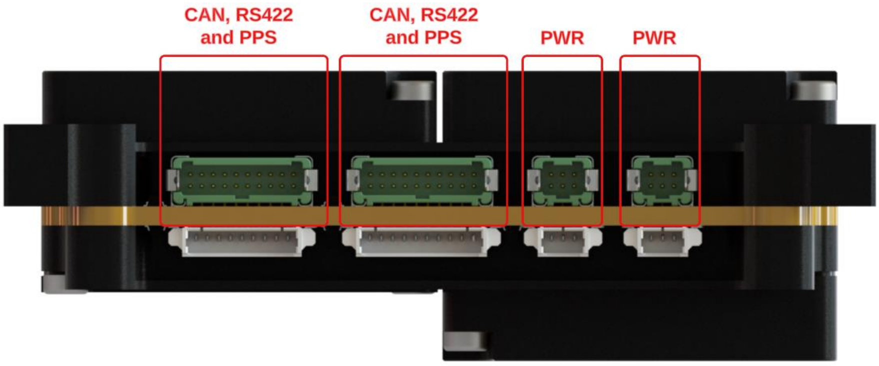


Figure 4-6: SDR MK3 NanoCom Link IS1 back side view.

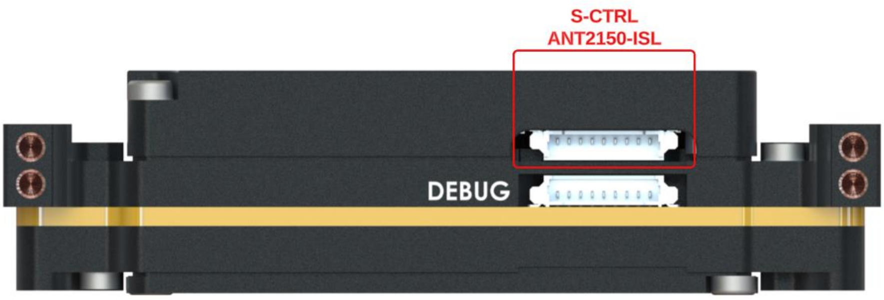


Figure 4-7: SDR MK3 NanoCom Link IS1 left side view.

4.1.2 NanoCom ANT2150

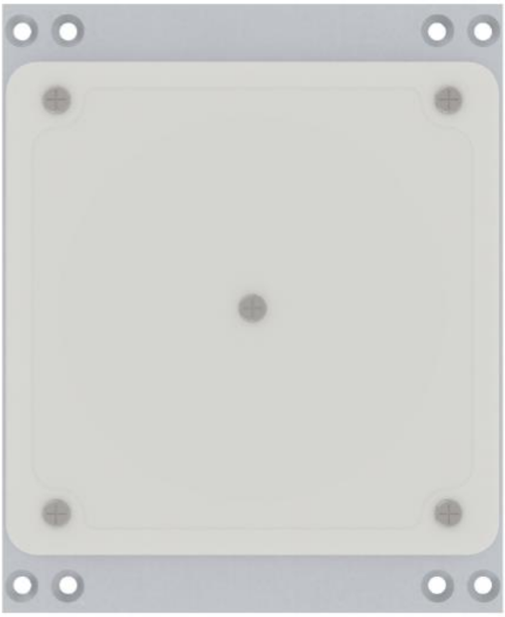


Figure 4-8: NanoCom ANT2150-ISL top view.

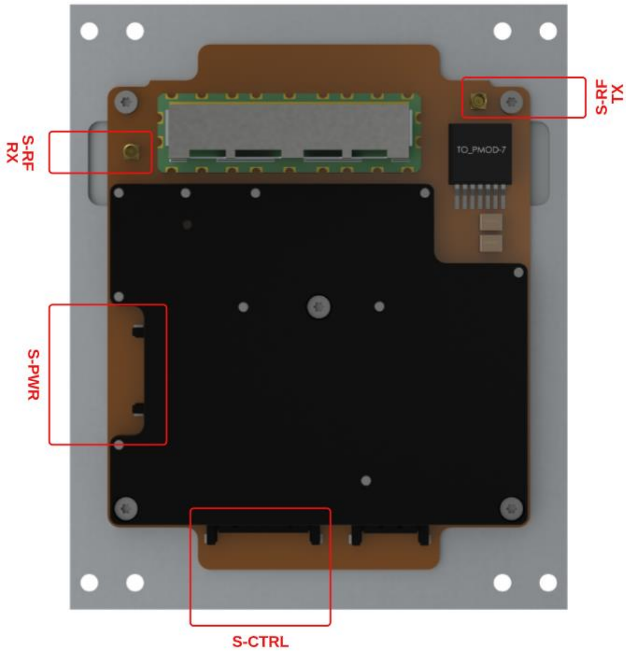


Figure 4-9: NanoCom ANT2150-ISL bottom view.

4.2 Power Interfaces

4.2.1 SDR MK3 PWR-1 and PWR-2

SDR MK3 is equipped with two Gecko G125-MH10605L1R 1.25mm pitch high-reliability connectors with latches from Harwin for external power supply. The board can be supplied through either connector, PWR-1 or PWR-2, using a single power supply or by connecting two independent power supplies for redundancy. A supply balancing circuit automatically selects whichever of the two power connectors that carries the highest VIN voltage as supply source. The load will be shared between the two power connectors if the external supply voltages VIN1 and VIN2 are of equal levels.

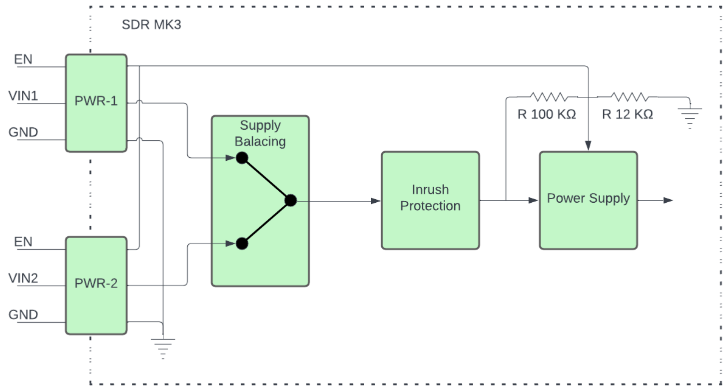


Figure 4-10: SDR MK3 power supply interface.

An external supply EN control pin makes it possible to enable or disable the DC/DC converter supplying the SDR MK3 independent of the supply voltage. The feature can be omitted by leaving the external EN control pin not connected.

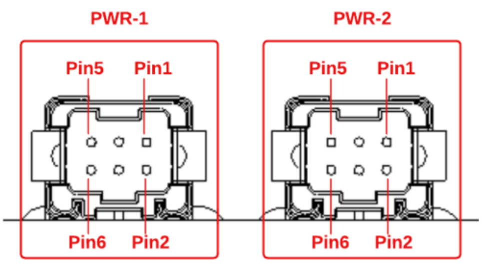


Figure 4-11: PWR-1 and PWR-2 connector pinout.

Pin	PWR-1 Signal	PWR-2 Signal	Description
1	VIN1	VIN2	Supply voltage (12V to 32V)
2	EN	EN	Supply enable signal, tied to Vin through a 100kohm / 12kohm divider. EN = 0V to 0.8V: Power supply / SDR MK3 is OFF EN = 1.2V to 24V: Power supply / SDR MK3 is ON EN = Not connected: Automatic supply switching, SDR MK3 is ON when supply voltage is above 10V and OFF below 8.5V.
3	VIN1	VIN2	Supply voltage (12V to 32V)
4	GND	GND	
5	VIN1	VIN2	Supply voltage (12V to 32V)
6	GND	GND	

4.2.2 ANT2150-ISL Power

ANT2150-ISL is powered via a PicoLock, 504050-0791, 1.50 mm pitch Molex connector.

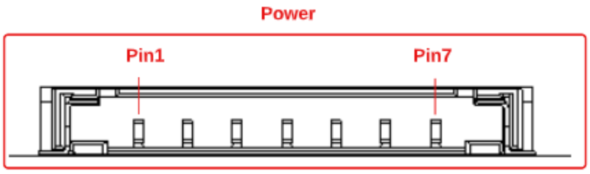


Figure 4-12: ANT2150-ISL S-PWR connector pinout.

Pin	Signal	Description
1	ABBON	External power control pin: Low < 0.4 V, High > 2.5 V (max 18V) Low: Antenna is OFF High: Antenna is ON (Antenna enters IDLE mode when AABON pin is asserted)
2	GND	
3	GND	
4	GND	
5	VIN	Supply voltage (8V to 18V)
6	VIN	Supply voltage (8V to 18V)
7	VIN	Supply voltage (8V to 18V)

4.3 Control and Data Interfaces

4.3.1 SDR MK3 CAN, RS422 and PPS

SDR MK3 is equipped with two Gecko G125-MH12005L1R 1.25mm pitch high-reliability connectors with latches from Harwin for access to its main communication interface. The individual pins of the two connectors are interconnected, which allow the SDR to be used in different bus topologies. The secondary connector can be used for interconnecting with other devices in multidrop bus configuration or for bus terminations if it's the last node in the system.

Of all the signals present in the main communication interface connectors, it is only CAN1 (Pin 2 and 4), RS422 (Pin 14, 16, 18 and 20) and PPS (Pin 9 and 11) that are used on NanoCom Link for control, data and time reference.

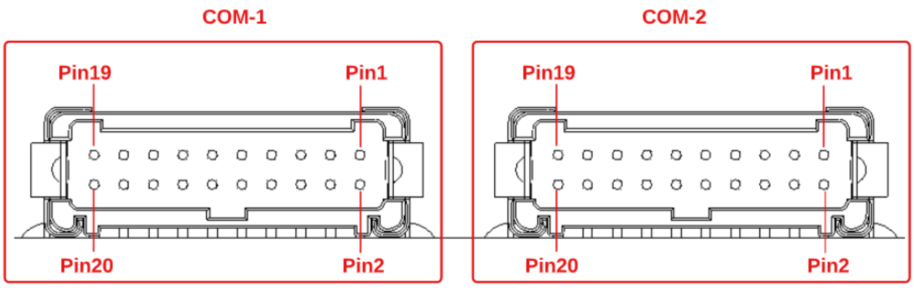


Figure 4-13: COM-1 and COM-2 pinout.

Pin	Signal	Description
1	I2C0-SDA	I2C0 serial data line
2	CAN1-P	CAN1 positive line used for CSP control interface
3	GND	
4	CAN1-N	CAN1 negative line used for CSP control interface
5	I2C0-SCL	I2C0 serial clock line
6	CAN2-P	CAN2 positive line dedicated frontend control via TR600[1]
7	GND	
8	CAN2-N	CAN2 negative line dedicated frontend control via TR600[1]
9	PPS-P	Pulse Per Second LVDS positive input line[2]
10	CLK-P	Ext reference clock LVDS positive input line
11	PPS-N	Pulse Per Second LVDS negative input line[2]
12	CLK-N	Ext reference clock LVDS negative input line
13	UART0-TX	Universal asynchronous transmitter output
14	RS422-TX-P	RS422 Noninverting driver output for payload data interface
15	GND	
16	RS422-TX-N	RS422 Inverting driver output for payload data interface
17	UART0-RX	Universal asynchronous receiver input
18	RS422-RX-P	RS422 Noninverting receiver input for payload data interface
19	GND	
20	RS422-RX-N	RS422 Inverting receiver input for payload data interface

Note 1: CAN2 is dedicated to frontend control on NanoCom Link. It should not be interconnected to other CAN networks. For proper operation a CAN network is to be equipped with 120ohm terminations on the outer ends. ANT2150-ISL is equipped a 120ohm CAN termination resistor. A termination plug equipped with a 120ohm resistor on CAN2 is included with the product and serves as SDR MK3 side terminator. The termination can be inserted into either COM-1 or COM-2.

Note 2: The PPS input is high impedance and without any differential termination resistor. PPS is to be terminated by a 100ohm resistor across the positive and negative terminals if distributed in a point-to-point network, or if the SDR MK3 is the last node in a multidrop network. A termination plug equipped with a 100ohm between PPS-P and PPS-N lines is included with the product and serves as SDR MK3 side terminator. The termination can be inserted into either COM-1 or COM-2.

4.3.2 SDR MK3 SpaceWire

SDR MK3 is equipped with three independent bi-directional, full-duplex SpaceWire interfaces for payload data transfer. It uses Gecko G125-MH11005L1R 1.25mm pitch high-reliability connectors with latches from Harwin for each of the three interfaces:

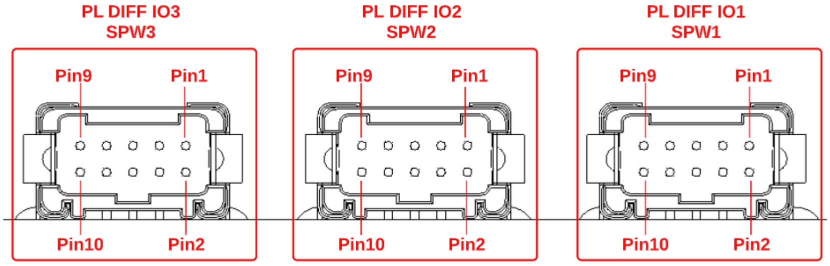


Figure 4-14 SPW1, SPW2 and SPW3 pinout.

Each SpaceWire interface uses two signals, data and strobe, in receive and transmit direction to send serial bit streams. The signals are based on low voltage differential signals according to the ANSI TIA/EIA-644 Standard and require two pins for each signal. The signals are named:

Pin	Signal	Description
1	Dout-	LVDS Data output negative line
2	Sin+	LVDS Strobe input positive line[1]
3	Dout+	LVDS Data output positive line
4	Sin-	LVDS Strobe input negative line[1]
5	GND	GND connection for inner cable shielding[2]
6	GND	GND connector for outer cable shielding[2]
7	Sout-	LVDS Strobe output negative line
8	Din+	LVDS Data input positive line[1]
9	Sout+	LVDS Strobe output positive line
10	Din-	LVDS Data input negative line[1]

Note 1: Din and Sin inputs are equipped with 100ohm termination resistors across the positive and negative terminals. The terminations reside internal to Z7000 and is realized using programmable logic. Meaning the SDR MK3 needs to be powered for the termination to be present. When unpowered the inputs are high impedance.

Note 2: Two pins for inner and outer cable shielding are available in each SpaceWire interface. A SpaceWire cable contain four twisted pair of wires with a characteristic impedance of 100ohm. In case of shielding, it's possible to use the GND pins to terminate inner (around each twisted pair) and outer shielding by connecting to those pins.

4.3.3 SDR MK3 Debug Interface

The SDR MK3 DOCK is equipped with a debug connector for production and debug purposes. It uses a Picoblade, 53261-0971 1.25mm pitch high-reliability connector from Molex:

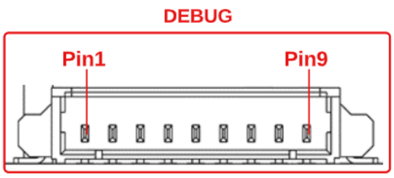


Figure 4-15 DEBUG connector pinout.

Pin	Signal	Description
1	TDO	JTAG Test Data Out
2	TCK	JTAG Test Clock
3	TMS	JTAG Test Mode Select
4	TDI	JTAG Test Data In
5	SYS_RST	System Reset
6	3.3V	3.3V from the NanoCom SDR
7	UART_RX	Debug UART Receive Line
8	UART_TX	Debug UART Transmit Line
9	GND	

Each NanoCom Link product is delivered with the required HW to interface between the debug UART and USB (DB1, DB2 and DB3 in Table 4-1). By connecting the USB to a PC it's possible to access the Linux command line interface on the SDR using a terminal program. The interface is not intended to be used in flight or integrated with the satellite bus.

4.3.4 SDR MK3 TR600 AFE Control Interface

Each TR600 module is equipped with two AFE CTRL connectors, dedicated configuration, and control of the RF frontends. It uses Picoblade, 53261-0971, 1.25mm pitch high-reliability connectors from Molex. The two connectors are interconnected and have similar pin-out.

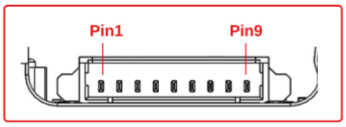


Figure 4-16 TR600 AFE CTRL connector pinout.

Pin	Signal	Description
1	CAN2-P	CAN2 positive line used for RF CSP control
2	CAN2-N	CAN2 negative line used for RF CSP control
3	GND	
4	I2C-SCL	I2C serial clock line used for RF CSP control
5	I2C-SDA	I2C serial data line used for RF CSP control
6	PSU	Output 4.6V power supply
7	AUXDAC2	TR600 transceiver AD9361-AUXDAC2
8	AUXADC	TR600 transceiver AD9361-AUXADC
9	GND	

ANT2150 S-CTRL interface uses CAN2-P, CAN2-N and GND for control and configuration.
The other pin / interfaces are not used on NanoCom Link IS1 and must be left "not connected".

4.3.5 ANT2150-ISL Control Interface

ANT2150-ISL is equipped with an S-CTRL connector, dedicated configuration, and control. It uses a PicoLock, 504050-1091, 1.5mm pitch high-reliability connector from Molex:

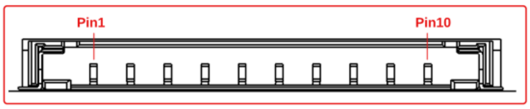


Figure 4-17 ANT2150-ISL S-CTRL connector pinout.

Pin	Signal	Description
1	GND	
2	GND	
3	I2C-SCL	I2C serial clock line
4	I2C-SDA	I2C serial data line
5	CAN2-N	CAN2 negative line used for RF CSP control
6	CAN2-P	CAN2 positive line used for RF CSP control
7	GND	
8	TXEN	TX Enable control pin
9	TXON	TX ON control pin
10	RXON	RX ON control pin

ANT2150-ISL uses CAN2-P, CAN2-N and GND for control and configuration.
The other pin / interfaces are not used on NanoCom Link and must be left “not connected”.

4.4 RF Interfaces

NanoCom Link is delivered with the required coax cables to interconnect SDR MK3 TR600 and ANT2150-ISL. The product is tested and qualified based with the characteristics of those specific cables.

SDR MK3 TR600	Connector	RF Frontend	Connector	Signal	Frequency
Slot A	T1	ANT2150-ISL	S-RF TX	S-RF TX	2200-2290 MHz
	R1		S-RF RX	S-RF RX	2200-2290 MHz

4.4.1 SDR MK3 TR600 RF Connectors

Each TR600 module is equipped with four SMPM RF connectors 925-126J-51P from Amphenol:

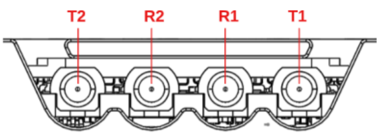


Figure 4-18 TR600 RF connector pinout.

RF Connector	Type	Manufacturer / Part Number	Description
T1	SMPM	Amphenol / 925-126J-51P	TR600 TX output 1.
R1	SMPM	Amphenol / 925-126J-51P	TR600 RX input 1.
T2	SMPM	Amphenol / 925-126J-51P	TR600 TX output 2.
R2	SMPM	Amphenol / 925-126J-51P	TR600 RX input 2.

4.4.2 ANT2150-ISL RF Connectors

ANT2150-ISL is equipped with two RF connectors 73413-0040 from Molex:

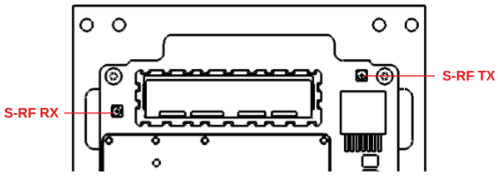


Figure 4-19 ANT2150-ISL RF connector pinout.

RF Connector	Type	Manufacturer / Part Number	Description
S-RF TX	SSMCX	Molex / 73413-0040	ANT2150-ISL TX frequency input from SDR MK3 TR600 T1 in Slot A.
S-RF RX	SSMCX	Molex / 73413-0040	ANT2150-ISL RX frequency output to SDR MK3 TR600 R1 in Slot A.

5 Electrical Characteristics

5.1 SDR MK3 Interfaces

Symbol	Connector	Parameter	Min	Typ	Max	Unit
V_{IN}	Power PWR-1 PWR-2	Supply voltage	12		32	V
I_{IN}		Supply current			1.0	A
EN_{THHIGH}		Enable signal threshold, EN rising	0.95	1.01	1.07	V
EN_{HYST}		Enable signal hysteresis		45		mV
$EN_{PIN\_CUR\_5V}$		EN pin current, EN=5V, VIN=12 to 32V	146		350	uA
$EN_{PIN\_CUR\_0V}$		EN pin current, EN=0V, VIN=12 to 32V	-320		-120	uA
SPW_{INDIFF}	SpaceWire PL DIFF IO1[1] PL DIFF IO2[1] PL DIFF IO3[1]	Differential input voltage, ICM=1.25V	100	350	600	mV
SPW_{INCM}		Input common mode voltage, IDIFF = ±350mV	0.3	1.2	1.425	V
SPW_{INTERM}		Input termination resistance		100		Ω
$SPW_{OUTDIFF}$		Differential output voltage, RT = 100Ω	247	350	600	mV
SPW_{OUTCM}		Output common mode voltage, RT = 100Ω	1.0	1.25	1.425	V
$RS422_{INDIFF}$	RS422 COM-1[2] COM-2[2]	Differential input threshold voltage	-0.2		0.2	V
$RS422_{INHYS}$		Differential input hysteresis		50		mV
$RS422_{INPV}$		Receiver Input voltage range	0		4	V
$RS422_{OUTDIFF}$		Differential output voltage, RT = 100Ω	±2.0			V
$RS422_{OUTCM}$		Output common mode voltage, RT = 100Ω			3	V
$CAN1\text{-}P_{OUT}$	CAN COM-1[3] COM-2[3]	CANH bus output voltage dominant	2.15	2.9	3.3	V
$CAN1\text{-}N_{OUT}$		CANL bus output voltage dominant	0.5	0.9	1.65	V
$CAN1_{OUTDIFF}$		Differential output voltage recessive, no RT	-0.5	0	0.05	V
$CAN1_{OUTCM}$		Common mode output voltage recessive and dominant, RT = 60 Ω	1.45	1.95	2.45	V
$CAN1_{INDIFF}$		Differential input threshold voltage	500		900	mV
$CAN1_{INHYS}$		Differential input hysteresis		150		mV
$CAN1_{INCM}$		Input common mode voltage			±25	V
PPS_{INPV}	PPS COM-1[4] COM-2[4]	Input voltage range	0		2.4	V
PPS_{INDIFF}		Differential input voltage range	100		600	mV
PPS_{INHYS}		Differential input hysteresis		100		mV
PPS_{ACC}		1Hz pulse deviation from GNSS time			±25	µSec
PPS_{DUR}		Pulse duration	1		999	msec

Note 1: In- and output lines are equipped with ESD protection to withstand ±25kV and comply with IEC 61000-4-2 level 4.

Note 2: The RS422 input on COM-1 and COM-2 is equipped with 120 Ω differential termination between RS422-RX-P and RS422-RX-N terminals (see Figure 5-1). For failsafe operation the differential input is equipped with a resistive divider network to terminate the input of the RS422 transceiver when nothing is connected. The resistive network consists of a 390Ω pullup via a schottky diode to 3.3V supply and a 390Ω pulldown to GND. In- and out-put lines are equipped with ESD protection to withstand ±15kV and comply with IEC 61000-4-2 level 4.

Note 3: The CAN1 port on COM-1 and COM-2 is without any differential termination between CAN1-P and CAN1-N terminals. Differential termination will have to be fitted externally at the outer ends of the CAN network. The inputs can withstand up to ±25kV HBM.

Note 4: The PPS port on COM-1 and COM-2 is high impedance and without any differential termination between PPS-P and PPS-N terminals. Differential termination, typically 100 ohm, will have to be fitted externally between PPS-P and PPS-N at the last receiving node of the PPS network. PPS input lines are equipped with ESD protection to withstand ±25kV and comply with IEC 61000-4-2 level 4.

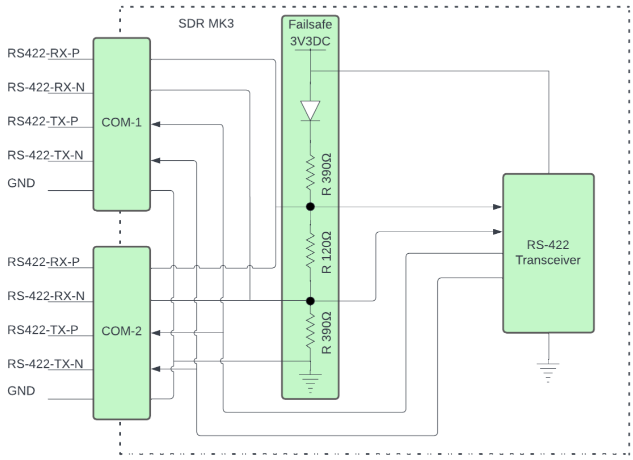


Figure 5-1 RS-422 COM-1 and COM-2 interface.

5.2 ANT2150-ISL Power Supply

Symbol	Connector	Parameter	Min	Typ	Max	Unit
V_{IN}	S-PWR	Supply voltage	8		18	V
I_{IN}		Supply current[1]			1.9	A
$V_{ABBON\text{-}HIGH}$		ABBON high level = Antenna is ON	2.5		18	V
$V_{ABBON\text{-}LOW}$		ABBON high level = Antenna is OFF	0		0.4	V
I_{ABBON}		ABBON input current 8-18V	0.06		0.8	mA

Note 1: VIN input sees about 2.2μF input capacitance, and additional 10μF when ABBON is asserted.

5.3 System Power Consumption

Power consumption is defined for three modes of operation:

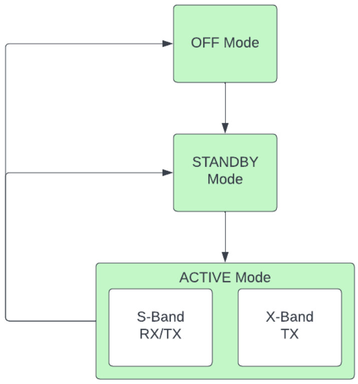


Figure 5-2: Modes of operation.

The modes are defined as:

OFF Mode	:	All supply voltages are present except for V_{SDR} which is powered OFF.
STANDBY Mode	:	All supply voltages are present. SDR build has booted and is idle waiting for commands on the control interface.
ACTIVE Mode	:	IS1 RF link is active.

The power consumption of the different modes is specified in Table 5-1

5.3.1 NanoCom Link IS1 Power Consumption

Typical values are expected average power consumption at +25°C. Min. and Max. are worst case power consumption across power level, frequency, and temperature extremes.
The return loss of the antenna is assumed to be -10dB or better.

Mode	Module	Net	VDC	Min	Typ	Max	Unit
OFF	SDR MK3	V_{SDR}	0	0.0	0.0	0.0	W
	ANT2150	$V_{MAIN-2150}$	8-18	0.1	0.1	0.3	W
STANDBY	SDR MK3	V_{SDR}	12-32	3.5	5.0	6.5	W
	ANT2150	$V_{MAIN-2150}$	8-18	0.1	0.1	0.3	W
ACTIVE	SDR MK3	V_{SDR}	12-32	4.5	5.5	7.0	W
	ANT2150	$V_{MAIN-2150}$	8-18	1.0	Refer to Table 5-2	7.0	W

Table 5-1: Power consumption specifications for NanoCom Link IS1.

Temperature	**+25°C**		**Unit**
TX PWR LVL	Min	Max	
0	1.5	1.8	W
1	1.6	1.8	W
2	1.6	2.0	W
3	1.7	2.1	W
4	2.1	2.7	W
5	2.2	2.8	W
6	2.3	3.1	W
7	2.4	3.1	W
8	3.3	4.1	W
9	3.4	4.2	W
10	3.6	4.5	W
11	3.8	4.7	W
12	4.0	4.8	W

Table 5-2: ANT2150 Typical Power Consumption for Power Level 0 to 12, $V_{MAIN-2150}$ = 12VDC.

Temperature	**+25°C**		**Unit**
TX PWR LVL	Min	Max	
0	0.2	0.3	A
1	0.2	0.3	A
2	0.2	0.3	A
3	0.2	0.3	A
4	0.3	0.4	A
5	0.3	0.5	A
6	0.4	0.5	A
7	0.4	0.5	A
8	0.5	0.7	A
9	0.6	0.8	A
10	0.6	0.8	A
11	0.7	0.8	A
12	0.7	0.9	A

Table 5-3: ANT2150 Typical Peak Current Draw for Power Level 0 to 12, $V_{MAIN-2150}$ = 12VDC.

6 RF Performance Characteristics

All performance parameters listed in this section refer to the RF output of AFE2150.

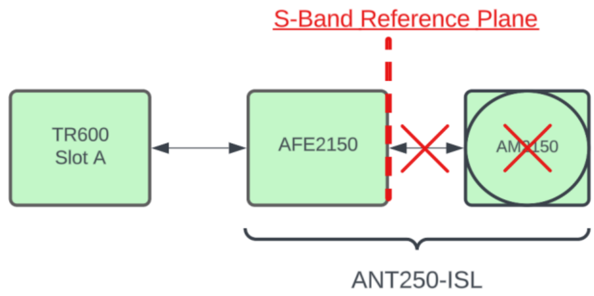


Figure 6-1: Reference plane RF performance characteristics.

6.1 S-Band Receiver

Unless otherwise stated the listed data is valid all supported temperatures, and supply voltages.

Symbol	Description	Min	Typ	Max	Unit
RX_{FREQ}[1]	RX Frequency Range	2200		2290	MHz
RX_{SYM}	RX symbol rate		100		kBd
RX_{BIT_BPSK}[2]	RX bit rate BPSK		100		kbit/s
RX_{Input_Level}	Maximum input level			-40.0	dBm
RX_{Noise_Figure}	System noise figure, RX_{Input_Level} ≤ -90dBm, T_{AMB} = +25°C		2.6	3.4	dB
	System noise figure, RX_{Input_Level} ≤ -90dBm, T_{AMB} = -40°C to +55°C			3.9	dB
RX_{Sens_Level}[3]	BPSK 100kBd, CC+RS coded		-114.0		dBm
RX_{FREQ_INIT}	Initial RX frequency error vs temperature	-6.0		+6.0	PPM
RX_{FREQ_AGE}	RX frequency error due to aging	-2.0		+2.0	PPM

Table 6-1: S-Band receiver characteristics.

Note 1: Effective RX frequency range which must cover 1.2xRX_{SYM}/2 of the received signal. E.g., for a RX symbol rate of 100kBd the lowest supported RX center frequency is 2201MHz and the highest supported RX center frequency is 2289MHz.

Note 2: Uncoded bit rate. Actual throughput is depending on coding and signalling overhead. Refer to section 8.2 for further information on achievable throughput.

Note 3: Input level where BER ≤ 10^{-6} at T_{AMB} = +25°C. Bits are concatenated coded with rate ½ convolutional inner code and Reed-Solomon (255,223) outer code, with an interleaving dept of 3 blocks.

6.2 S-Band Transmitter

The S-Band transmitter has thirteen power level settings, 0 to 12, for controlling the RF output power.
Unless otherwise stated the listed data is valid for the payload part of the TX burst, all supported temperatures, and supply voltages.

Symbol	Description	Min	Typ	Max	Unit
TX_{FREQ}[1]	TX Frequency Range	2200		2290	MHz
TX_{SYM}	TX symbol rate		100		kBd
TX_{BIT_BPSK}[2]	TX bit rate BPSK		100		kbit/s
TX_{Pout_Nom}[3]	Nominal TX PWR LVL 0 to 12 range	20.0		31.5	dBm
TX_{Pout_Step}[3]	TX PWR LVL 0 to 12 step size	0.25	1	1.5	dB
TX_{Pout_Freq}[3]	Frequency variation TX PWR LVL 0	-2		2	dB
TX_{Pout_Temp}[3]	Temperature variation TX PWR LVL 0	-1		1	dB
TX_{OCP_BW}	99% Occupied BW, 100kBd		120		kHz
TX_{ACPR}[4]	Adjacent channel power ratio			-20	dBc
TX_{SPUR_EM}[5]	TX spurious emission			-15	dBm
TX_{FREQ_INIT}	Initial TX frequency error vs temperature	-6.0		+6.0	PPM
TX_{FREQ_AGE}	TX frequency error due to aging	-2.0		+2.0	PPM

Table 6-2: S-Band transmitter characteristics.

Note 1: Effective TX frequency range which must cover 1.2xTX_{SYM}/2 of the transmitted signal. E.g., for a TX symbol rate of 100kBd the lowest supported TX center frequency is 2201MHz and the highest supported TX center frequency is 2289MHz.

Note 2: The actual throughput is depending on coding and signalling overhead. Refer to section 8.2 for further information on achievable throughput.

Note 3: Refer to Table 6-3 for further details on typical S-Band TX RF output power. NanoCom Link IS1 is operating the TX power control in open loop. Therefore, any changes to the characteristics of the S-RF cable delivered with the product Table 4-1, can affect the output power level.

Note 4: Refer to Figure 6-2 for further details on typical TX output spectrum.

Note 5: TX spurious emission according to ITU-R SM.329.

6.2.1 TX Channel Power

Typical channel power at TX_{FREQ} = 2245MHz, $V_{MAIN-2150}$ = 12VDC and T_{AMB} = +25°C.

TX PWR LVL	Typ	Unit
12	31.5	dBm
11	31.0	dBm
10	30.0	dBm
9	29.0	dBm
8	28.0	dBm
7	27.0	dBm
6	26.0	dBm
5	25.0	dBm
4	24.0	dBm
3	23.0	dBm
2	22.0	dBm
1	21.0	dBm
0	20.0	dBm

Table 6-3: Typical TX Channel Power for TX PWR LVL 0 to 12.

6.2.2 TX Output Spectrum

Typical output spectrum measured gated in the payload part of the TX burst while transmitting PRBS data. TX_{FREQ} = 2245MHz, $V_{MAIN-2150}$ = 12VDC and T_{AMB} = +25°C.

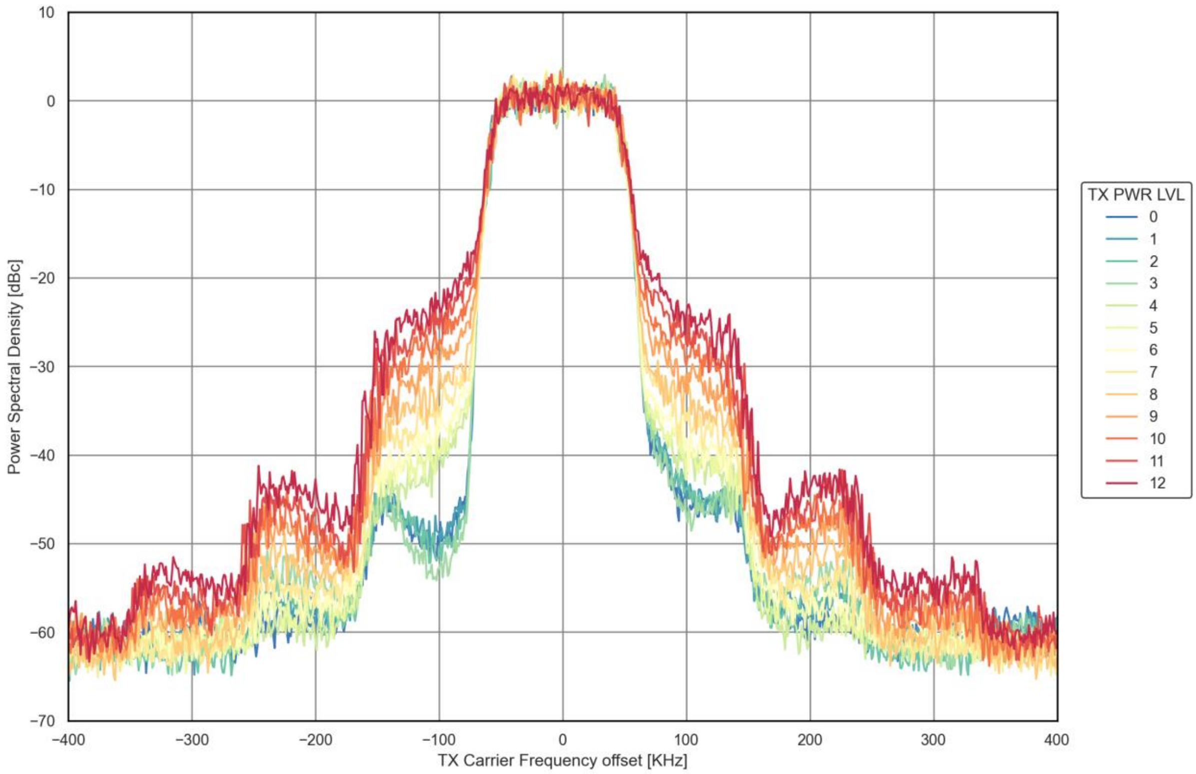


Figure 6-2: Typical TX Output Spectrum for TX PWR LVL 0 to 12.

7 Antenna Performance Characteristics

ANT2150-ISL is equipped with a left hand circular polarized patch antenna. Key performance of the antenna element is listed below including plots of measured data on realized gain, axial ratio, and half power beamwidth. The propagation direction theta = 0deg is perpendicular to the face of the antenna.

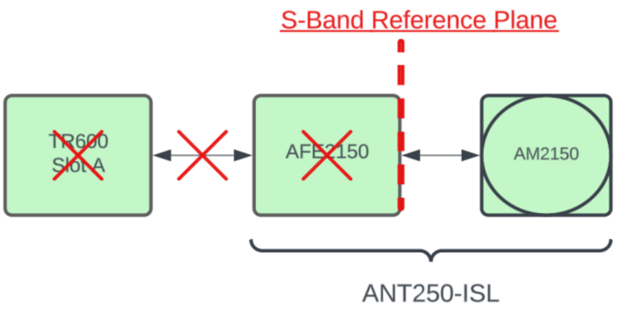


Figure 7-1: Reference plane antenna performance characteristics.

7.1 S-Band Patch (AM2150)

The S-Band patch is Left Hand Circular Polarized.

Parameter	Min	Max	Unit
Frequency range	2200	2290	MHz
Realized gain, theta = 0deg	7	-	dBi
Axial ratio, theta = 0 to ±40deg	-	6.5	dB
Half power beamwidth	55	75	deg
Insertion loss feed	-	0.5	dB

Table 7-1: S-Band patch antenna characteristics.

7.1.1 S-Band Realized Gain

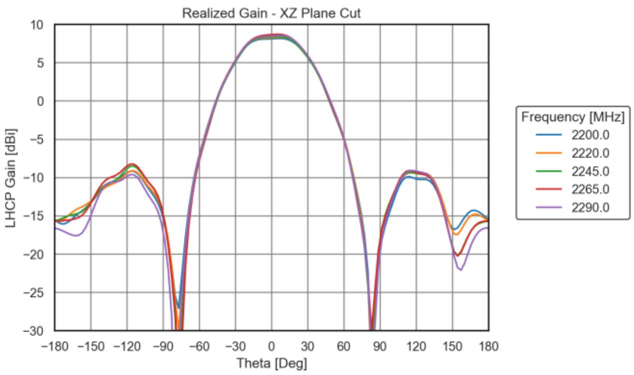


Figure 7-2: S-Band realized gain vs Theta, XZ plane.

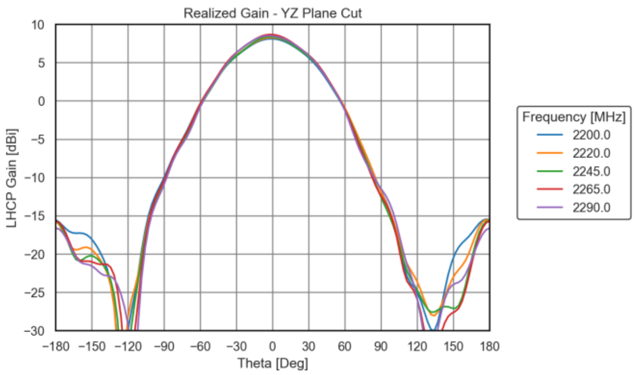


Figure 7-3: S-Band realized gain vs Theta, YZ plane.

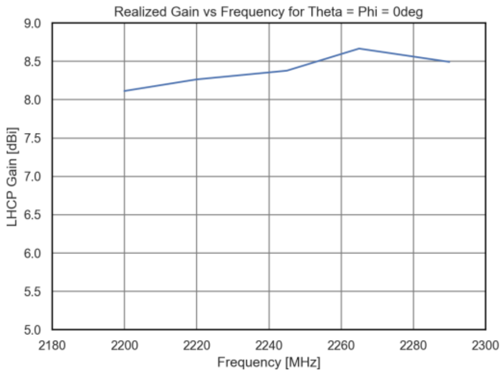
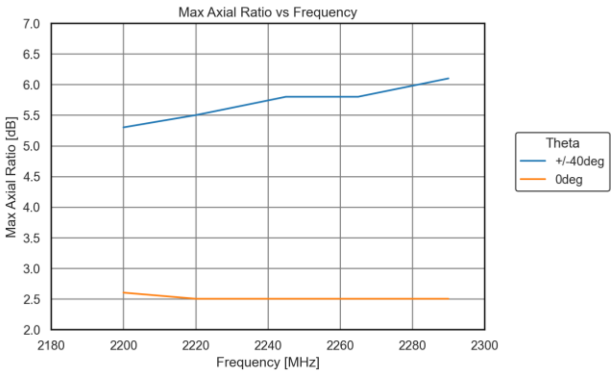


Figure 7-4: S-Band realized gain for Theta=Phi=0deg.

7.1.2 S-Band Axial Ratio



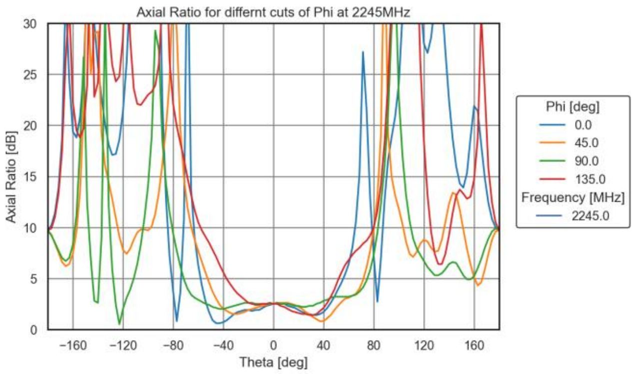


Figure 7-5: S-Band max axial ratio vs frequency.

Figure 7-6: S-Band axial ratio at 2245MHz.

7.1.3 S-Band Half Power Beamwidth

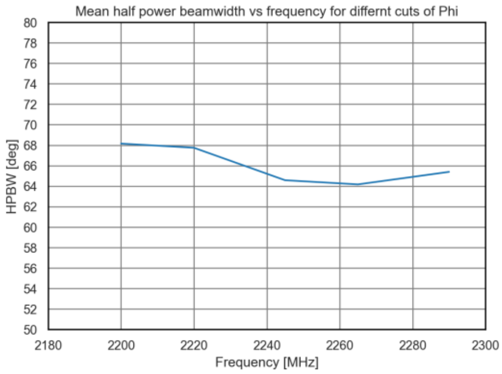


Figure 7-7: S-Band half power beamwidth.

8 Processing System Performance

8.1 Storage Performance

eMMC	Access Mode	Read	Write	Read/write
Primary	Sequential	184 Mbit/s	168 Mbit/s	88/88 Mbit/s
Secondary	Sequential	184 Mbit/s	168 Mbit/s	88/88 Mbit/s
Primary	Random	176 Mbit/s	168 Mbit/s	88/88 Mbit/s
Secondary	Random	176 Mbit/s	168 Mbit/s	88/88 Mbit/s
Striped	Sequential	360 Mbit/s	326 Mbit/s	167 Mbit/s
Striped	Random	380 Mbit/s	346 Mbit/s	180 Mbit/s

Table 8-1: Storage performance.

The Striped eMMC storage performance is achieved with a storage volume that logically spans both Primary and Secondary eMMC to achieve increased read and write performance compared to using a volume on a single eMMC. A Striped volume is intended for payload data only e.g. data to be downlinked with X-band at rate exceeding the single eMMC read rates.

The eMMC performance characteristics are derived using the “fio” benchmarking application. See https://fio.readthedocs.io/en/latest/fio_doc.html.

8.2 Data Transfer Performance

Interface	Data transfer rate	Transfer scenario
SpaceWire (file)	145 Mbit/s @ 1 MB files 155 Mbit/s @ 5 MB files 155 Mbit/s @ 100 MB files	File dump to striped eMMC.
SpaceWire (IP)	One interface streaming in one direction: 150 Mbit/s Three interfaces streaming in one direction: 150 Mbit/s per interface Three interfaces streaming in both directions: 80 Mbit/s per interface	Measured using iperf3. All rates apply for UDP and TCP.
RS422 (IP)	80.6 Kbit/s @ 115.2 kBd 0.70 Mbit/s @ 1 MBd 1.40 Mbit/s @ 2 MBd 2.10 Mbit/s @ 3 MBd	Measured using iperf3 configured to use TCP/IP.

Table 8-2: Data transfer rate.

Protocol	Data transfer rate	Transfer scenario
IP	7.5 kbit/s	Bi-directional data transfer.

Table 8-3: S-Band data transfer rate.

9 Mechanical Characteristics

All dimensions are in mm.

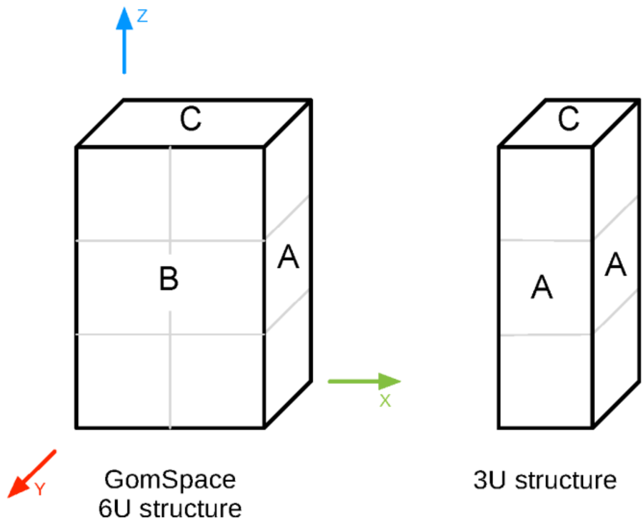


Figure 9-1: Antenna mounting plate Type ABC and XYZ side definitions.

Different mounting plates are available for ANT2150-ISL to support direct placement on the X/Y/Z sides of standard GomSpace structures. Other mounting configurations are possible by using custom adaptation between the antenna mounting plate and structure.

When purchasing the product, it is possible to select between the different mounting plates using the option sheet.

9.1 SDR MK3 – NanoCom Link IS1

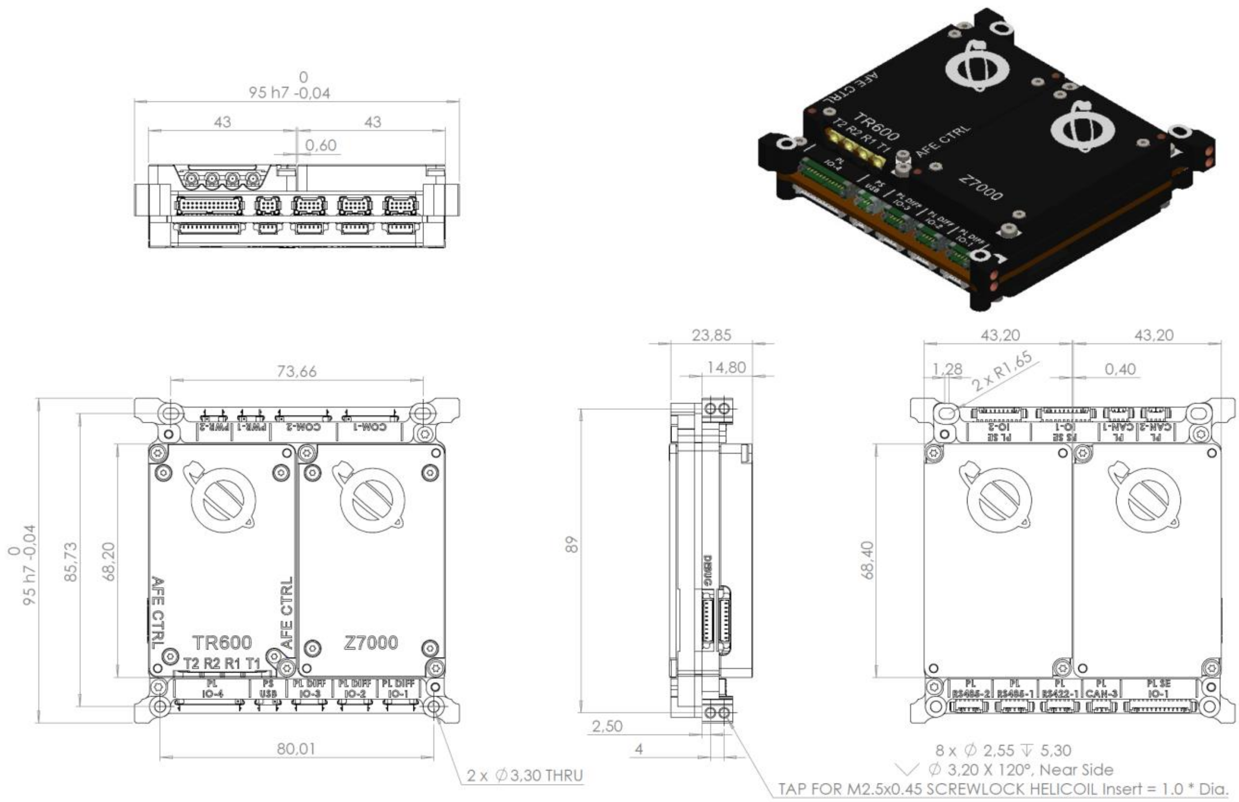


Figure 9-2: SDR MK3 – NanoCom Link IS1.

9.2 ANT2150 Backplate X and Y

ANT2150 backplate for X or Y side mounting on GomSpace 3U and X side mounting on GomSpace 6U structure. Type A backplate in option sheet.

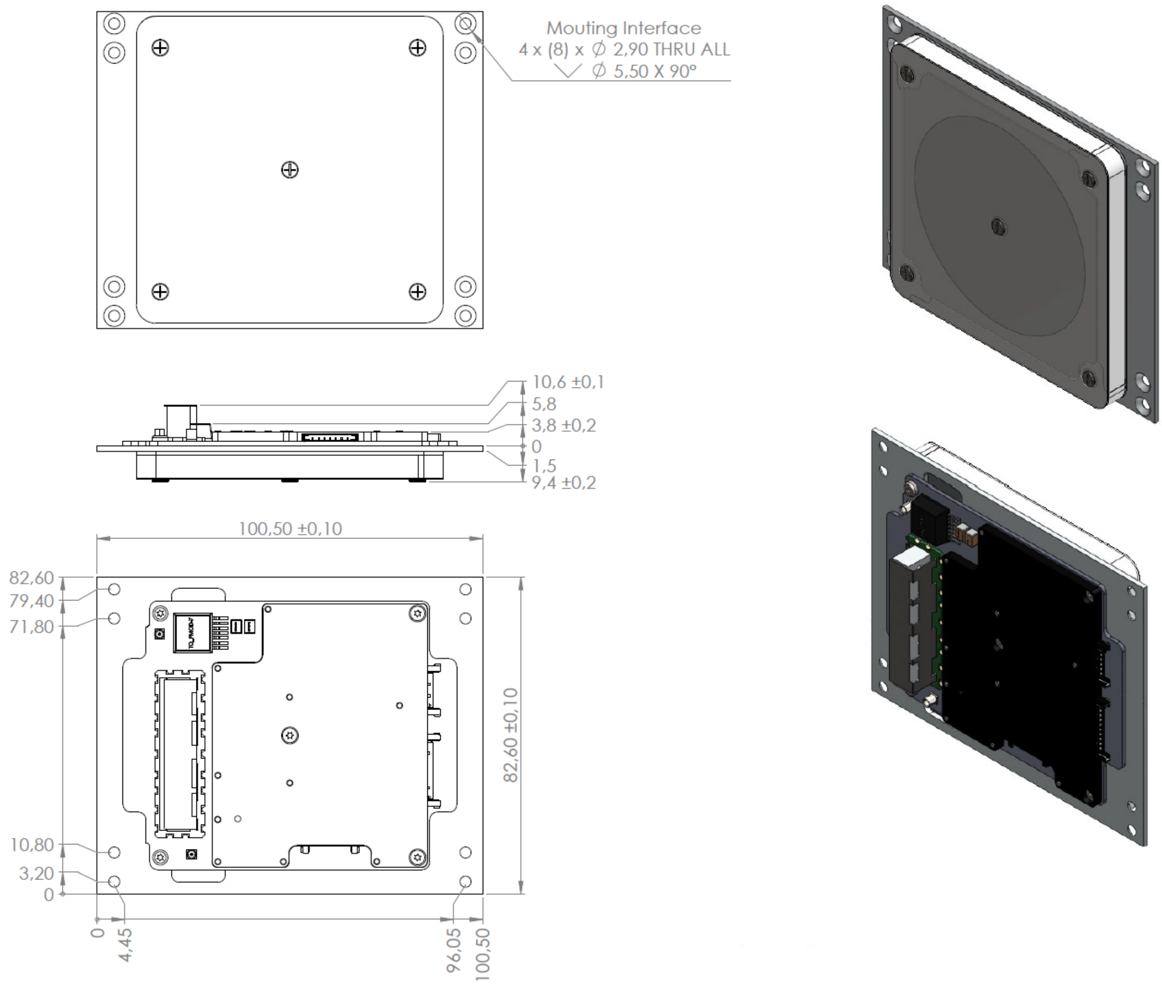


Figure 9-3: ANT2150 Backplate Type A.

9.3 ANT2150 Backplate Z

ANT2150 backplate for Z side mounting on GomSpace 3U structure. Type C backplate in option sheet.

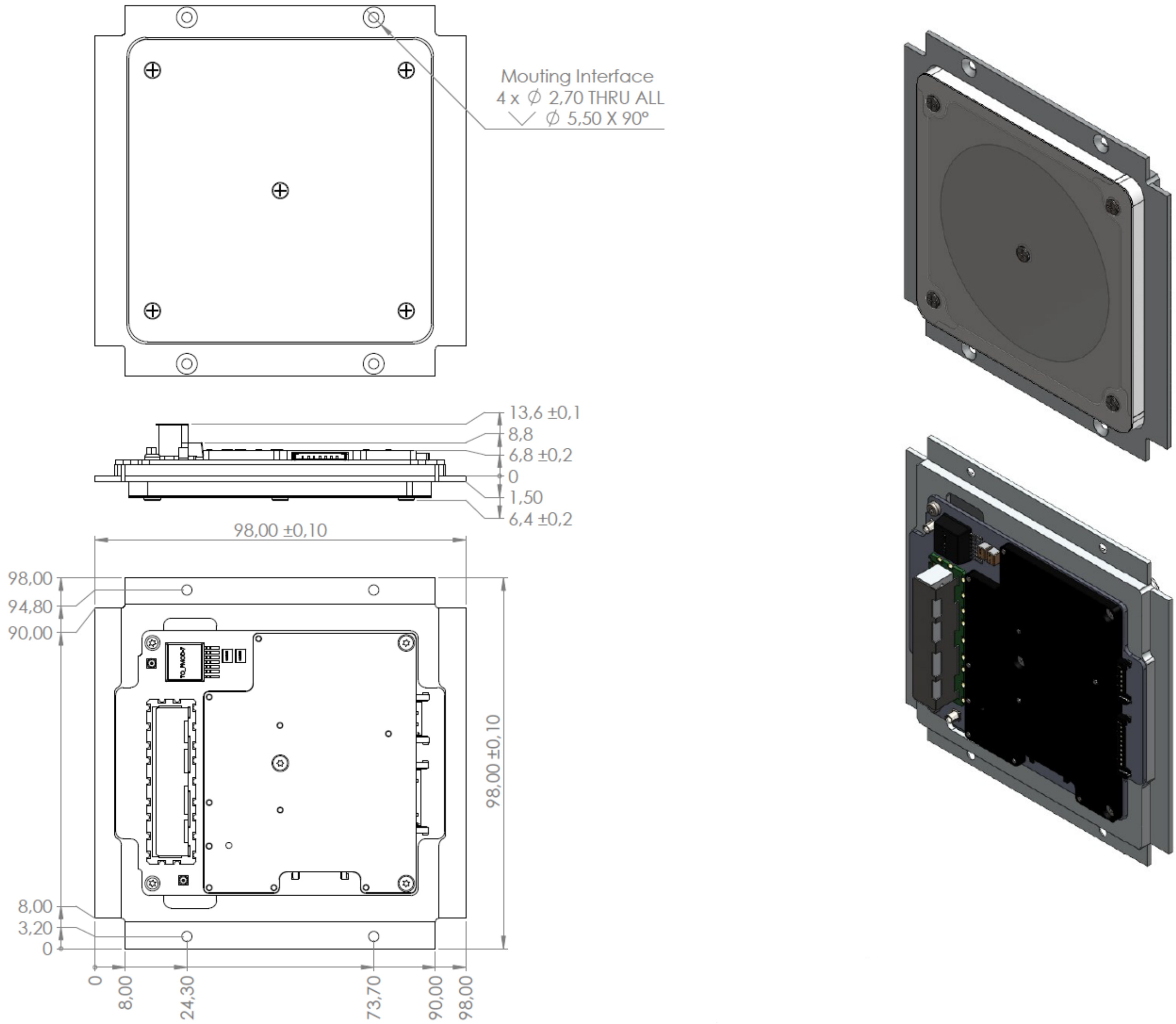


Figure 9-4: ANT2150 Backplate Type C.

10 Mass

Below is an overview of the typical mass of the different configurations of NanoCom Link. All readings have been rounded up to the nearest whole number.

10.1 SDR MK3

Variant	Mass	Unit
NanoCom Link IS1	272	g

Table 10-1: SDR MK3 mass.

10.2 ANT2150-ISL

Mounting Configuration	Mass	Unit
Type A	112	g
Type C	123	g

Table 10-2: ANT2150-ISL mass.

10.3 Product Cable Kit

The mass of the different cables, except those intended for debug only, are listed below.

ID	Description	Mass	Unit
PWR	SDR MK3 power to flying leads	6	g
S-PWR	ANT2150 power to flying leads	6	g
S-RF	RG-178 Coax cable, SSMCX to SMPM	6	g
S-CTRL	TR600 MK3 to ANT2150 control harness	4	g
TERM2	SDR MK3 Mainbus CAN2 and PPS termination	2	g

Table 10-3: Product cable kit mass.

11 Qualifications

The individual devices of NanoCom Link have been exposed to several environmental tests to simulate the harsh conditions of launch and space. Contact GomSpace for further information.

12 Revision History

Revision	Date	Description
1.0	08-02-2024	Preliminary release.
2.0	05-11-2024	Updated S-band initial RX and TX frequency error vs temperature Table 6-1 and Table 6-2 from +/-3.0 to +/- 6.0PPM.

13 Disclaimer

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