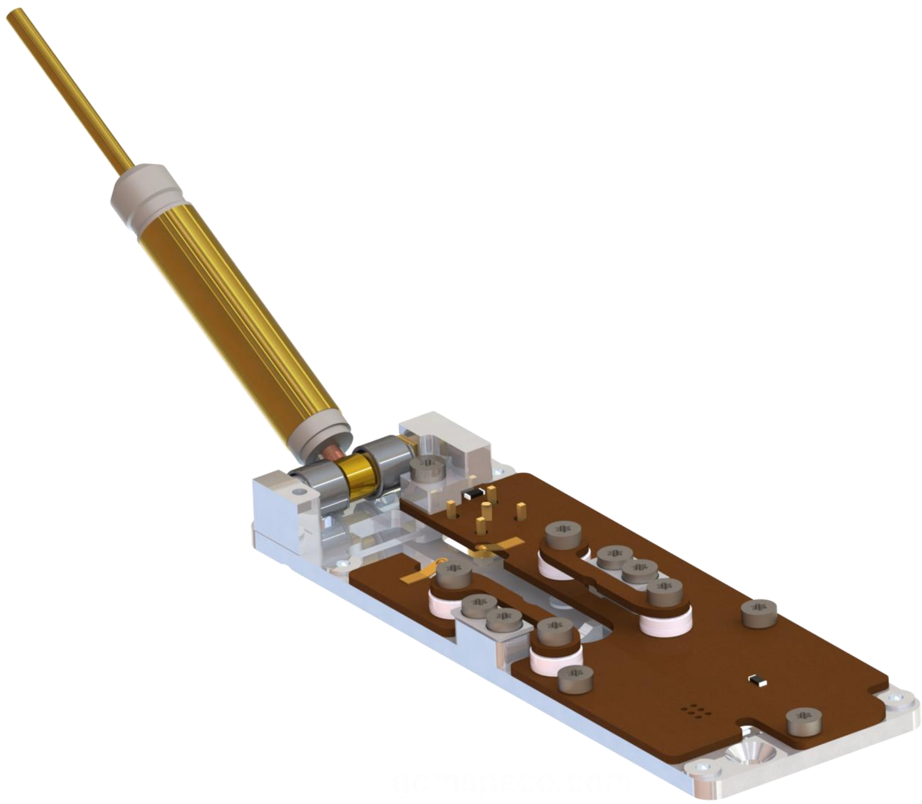

NanoCom
AM2150-O Antenna System

Datasheet

Product name: AM2150-O

Document No.: 1033547

Revision: 1.1

Author: ROBB

Approved by: FIHA

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Table of Contents

1 Overview

The NanoCom AM2150-O is an S-band antenna solution based on a 1/4-wave sleeved dipole type of antenna element.

The radiation pattern of the antenna element is similar to that of a half wave dipole. Depending on the orientation of the antenna and interaction with the exterior of the spacecraft, the antenna gives a near omni-directional radiation pattern.

During launch, the antenna element is stowed to minimize the space occupied by the antenna system. Once deployed into orbit, it’s possible to command and monitor the release of the antenna element via the GOMspace release bus. Once released, the antenna element will rotate 150 degrees, around a spring loaded SMP based connecter, and transition from stowed to a position outside the spacecraft.

AM2150-O is compatible with 1U, 2U, 3U, 6U and 12 U structures, where it’s possible to fit the antenna system in a variety of locations and orientations. The optimum placement should be selected based on the resulting radiation pattern, ground station polarization and satellite orientation.

The antenna system is designed to complement the AX2150 low power radio but will work with other radio systems as well. It can be used stand alone or in combination with other AM2150-O, to further tune the resulting radiation pattern.

1.1 Highlighted Features

- Deployable antenna designed with low loss materials
- Coverage 2025 – 2290 MHz
- Radiation pattern: near omni-directional depending on placement
- Redundant release mechanism
- Choice of mounting plates for different mounting locations.
- The mounting plates have a selection of interface to other GomSpace modules such as, GPS, Flight preparation panel, Fine sun sensor, etc.

1.2 Functional Description

AM2150-O consist of a sleeved dipole type of antenna element. This configuration has been selected to minimize effect of the ground plane (exterior of the spacecraft) on the resonance frequency of the antenna. The element is designed to operate within the 2025-2290MHz frequency band, matching the RX / TX frequency range of the GomSpace AX2150 TMTC transceiver.

A MCX coaxial connector, placed on the bottom side of the main board, is used to interface to the antenna element. During launch the antenna element is stowed parallel to the main board to save space.

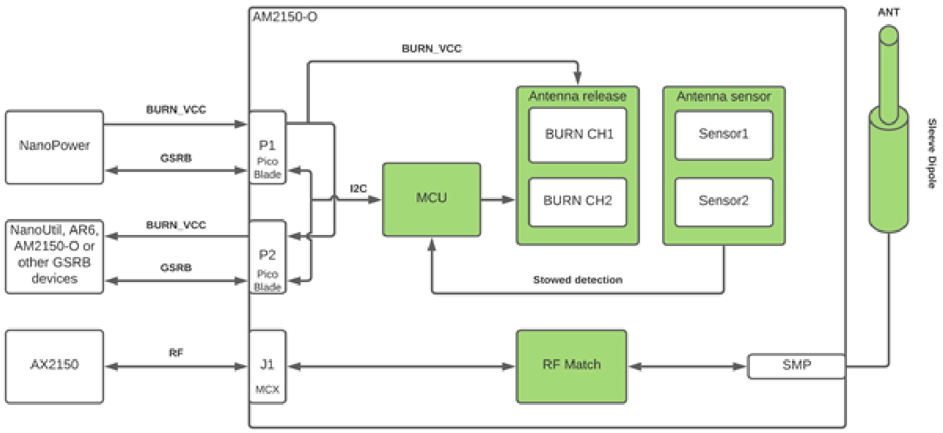


Figure 1-1. AM2150-O Block Diagram

The antenna element is fixated to stowed position by a Dyneema monofilament line. A clamp on each side of the antenna element, and curvature on the middle part of the antenna element assembly, keeps the line into place. The line is routed across the top of the housing of two SMD resistors located on small PCBs on each side of the antenna element. Each resistor has an associated burn channel.

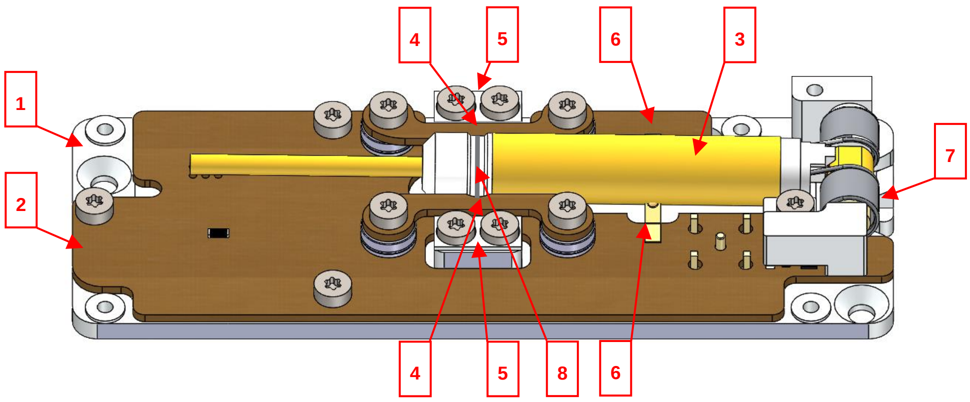


Figure 1-2. AM2150-O 3DCAD Stowed

1. Mounting Plate
2. Main Board
3. Antenna Element
4. Burn CH1 & Burn CH2
5. Burnwire Clamps
6. Sensor 1 & Sensor 2
7. SMP based spring loaded hinge
8. Dyneema monofilament line

The burn and sensor channels are controlled and monitored by an onboard MCU, which has inherited its firmware from NanoUtil AR6, the flight proven GomSpace release mechanism used for the VHF version of ANT-6F. Via the GomSpace Release Bus interface and AR6 firmware, it's possible to control and monitor the state and status of the antenna. Once in orbit, each of the burn channels can be activated sequential, by issuing a burn command or by the build-in backup deployment functionality in case of a malfunction.

Once deployed, the monofilament line can easily be replaced allowing up to eight activations per burn resistor to test antenna release during assembly, integration and verification of the spacecraft.

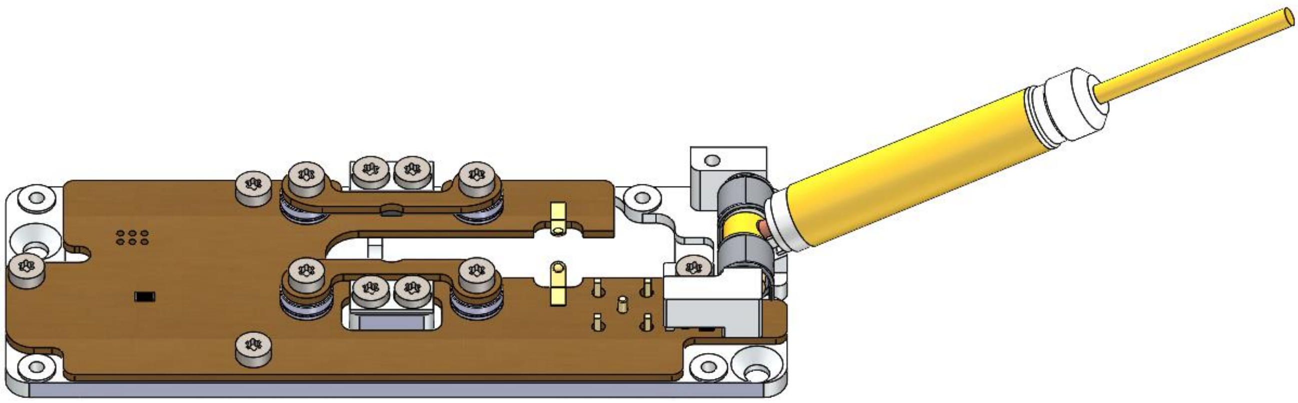


Figure 1-3. AM2150-O 3DCAD Deployed

A spring loaded SMP connector serve as hinge and interface the antenna element to the SMP connector on the bottom side of the PCB. The antenna element transition 150degrees from its stowed to deployed position.

The antenna element is linear polarized and has an omnidirectional shaped radiation pattern in free space. Once placed on an electromagnetic reflective object, like the body of a spacecraft, solar panel, or other antennas the pattern will get distorted. The resulting pattern is bound to have areas with higher or lower gain. Careful placement of the antenna is therefore necessary to ensure optimum coverage, relative to the link requirements imposed by a particular mission. It is possible to use more antennas in combination, to further tune the resulting radiation pattern. The feed network required to interconnect the RF interface of two or more AM2150-O is not included and will have to be provided externally.

1.3 Application Example

An example of the total radiated field with AM2150-O mounted on top +X quadrant, on the A side of a GomSpace 6U structure with deployed solar panel in the -X direction is shown in
Figure 1-4. The pattern has been simulated using CST Microwave Studio. The pattern shows the antenna has a null point in the direction which the tip of the antenna element points. And the solar panel acts as a director causing a high gain region in the -X direction.

Looking at entire sphere, and assuming -12dBi antenna gain is required to establish a link, the resulting link probability for a tumbling satellite is:

- LHCP or RHCP gain > 80% of directions
- Absolute gain > 95% of directions

During nominal flight, assuming the +X side of the satellite is ground station pointing, link requirement is fulfilled as well.

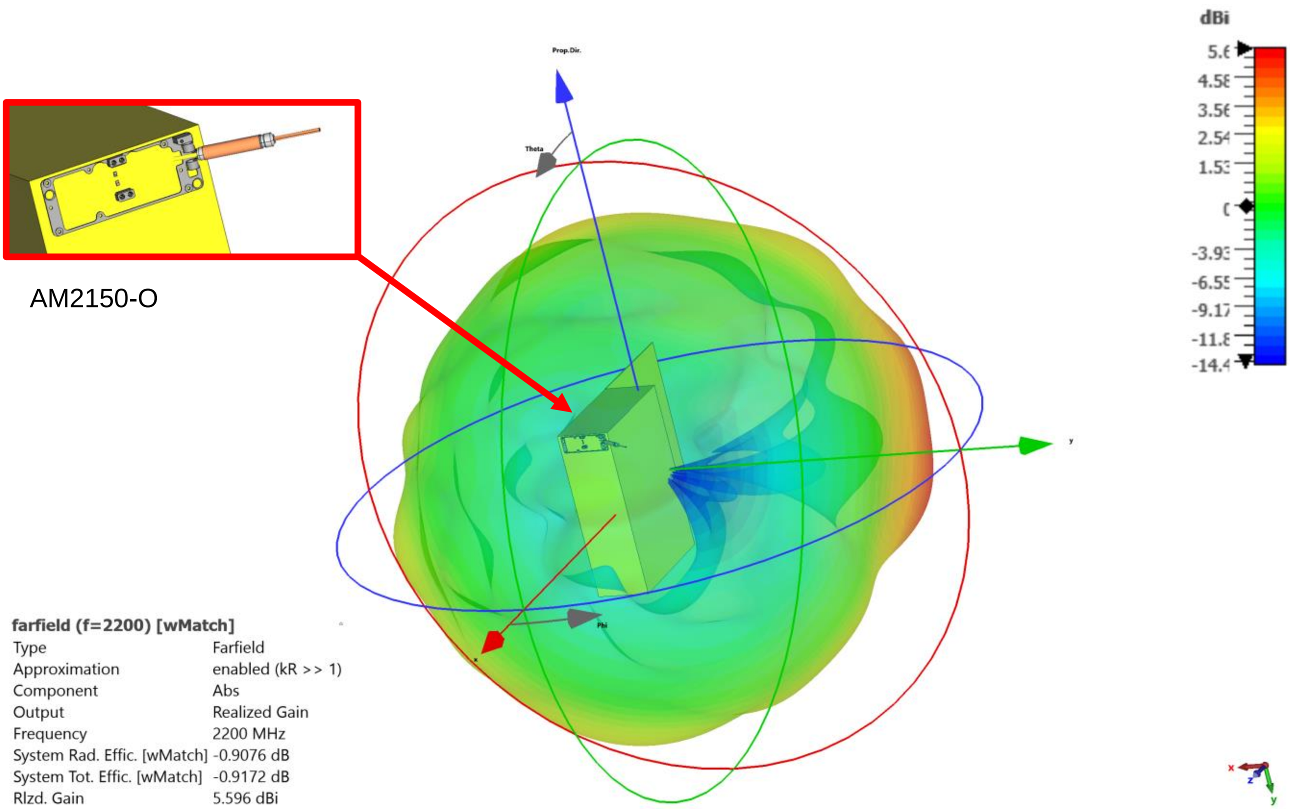


Figure 1-4. AM2150-O ABS radiation pattern at 2200MHz, on 6U with deployable solar panel.

2 Hardware Layout, Connectors

The bottom side of the AM2150-O contains the GSRB and RF interface connectors.

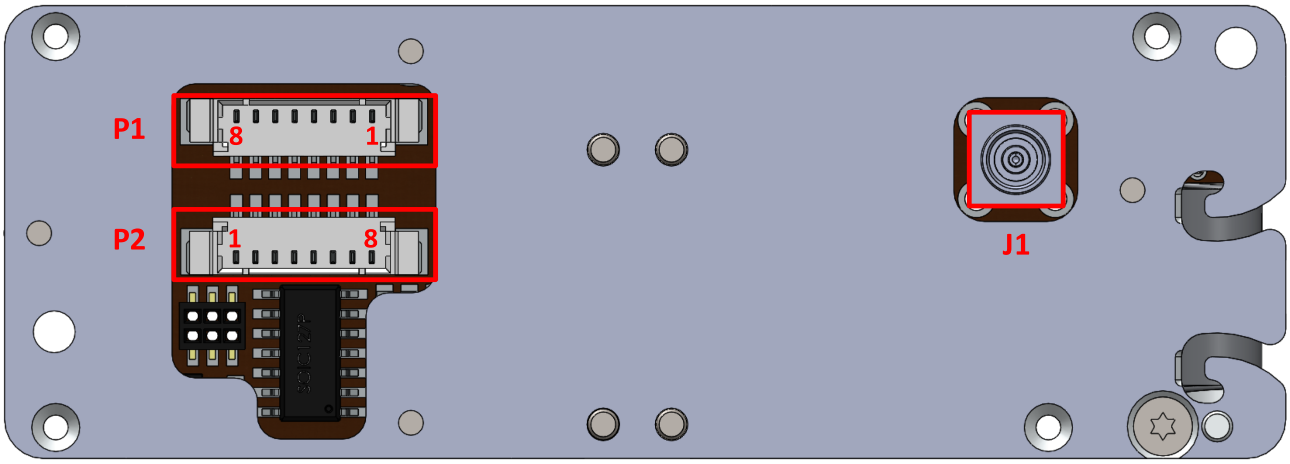


Figure 2-1. AM2150-O bottom side view.

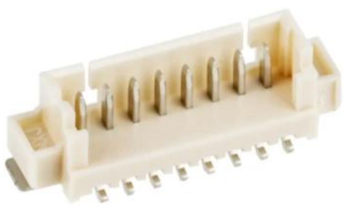
P1 and P2	J1
Molex 53398-0871 8pin 1.25mm pitch PicoBlade Header.	Samtec MCX-J-P-H-ST-TH1 50ohm MCX jack, female socket.
	

Figure 2-2. Connectors.

2.1 P1 – GSRB BUS

GomSpace release bus connector.

Pin	Name	Description
1	GSRB_SDA	MCU I2C Data
2	GSRB_SCL	MCU I2C Clock
3	GSRB_VCC	MCU Supply
4	GSRB_GND	MCU Ground (interconnected with Burn Ground)
5	BURN_VCC	Burn Supply
6	BURN_VCC	Burn Supply
7	BURN_GND	Burn Ground
8	BURN_GND	Burn Ground

BURN_GND and GSRB_GND nets are electrical connected to the back plate / satellite structure though a 4.7Kohm resistor to minimize stray currents.

2.2 P2 – GSRB BUS

GomSpace release bus connector.

Pin	Name	Description
1	BURN_GND	Burn Ground
2	BURN_GND	Burn Ground
3	BURN_VCC	Burn Supply
4	BURN_VCC	Burn Supply
5	GSRB_GND	MCU Ground (interconnected with Burn Ground)
6	GSRB_VCC	MCU Supply
7	GSRB_SCL	MCU I^2C Clock
8	GSRB_SDA	MCU I^2C Data

BURN_GND and GSRB_GND nets are electrical connected to the back plate / satellite structure though a 4.7Kohm resistor to minimize stray currents.

2.3 J1 - Antenna

50 ohm MCX connector.

Pin	Description
Centre	Inner conductor
Sleeve	Outer Shield / RF Ground

The RF ground is electrical connected to the back plate and exterior of the spacecraft.

3 Absolute Maximum Ratings

Symbol	Description	Conditions	Value	Unit
P_{max}	Maximum input power J1 MCX	Average	5	W
T_{op}	Operating temperature		-40 to 85	°C
$T_{storage}$	Storage temperature		-40 to 85	°C
$B_{duration1ATM}$[1]	Burn time duration standard pressure	1 atm pressure	10	Sec
$B_{duration0ATM}$[1]	Burn time duration in vacuum	0 atm pressure	6	Sec
B_{num}[1]	Number of activations times each burn resistor		8	

1) Exceeding the maximum burn time duration and activation times will degrade the lifetime and reliability of the burn resistor. The maximum burn duration is pre-configured to 10sec in the settings register (AR6 SW). During testing, it's generally recommended to stop a burn as soon as the antenna is detected to be released.

4 GSRB Characteristics

Symbol	Description	Min	Typ	Max	Unit
VCC	GSRB Supply Voltage		3.3		V
ICC	GSRB Supply Current		5	50	mA
$5V_{VBURN}$	VBURN supply voltage 5V option	4.5	5	5.5	V
$5V_{IBURN}$	VBURN supply current 5V option	315	500	715	mA
$8V_{VBURN}$	VBURN supply voltage 8V option	6	8	8.4	V
$8V_{IBURN}$	VBURN supply current 8V option	175	333	455	mA
$16V_{VBURN}$	VBURN supply voltage 16V option	12	16	16.8	V
$16V_{IBURN}$	VBURN supply current 16V option	102	195	266	mA
$32V_{VBURN}$	VBURN supply voltage 32V option	24	32	33.6	V
$32V_{IBURN}$	VBURN supply current 32V option	51	97	132	mA

5 RF Characteristics

For a tumbling satellite where the direction towards the ground station is more or less random the antenna system gain will have to be evaluated using a statistical approach resulting in a "link probability". Complementary Cumulative Distribution Function of antenna gain indicates the probability that the antenna gain takes on a certain value assuming a tumbling satellite.

Symbol	Description	Conditions	Value	Unit
Z_o	Nominal impedance		50	Ω
|S11|	Input matching J1 MCX @ 2025-2290MHz	All	< -10	dB
$G_{a,sys}$	ANT2150-O antenna gain on 3U or 6U Structure	> -12 dBi	80	% of directions

5.1 CCDF Plots

Below are CCDF plots on RHCP, LHCP and ABS gain for selected satellite configurations. The data for the plots are based on simulation. Four frequencies 2020, 2110, 2200 and 2290MHz have been simulated and the resulting gain pattern have been analysed in terms of CCDF for a 1deg spatial resolution.

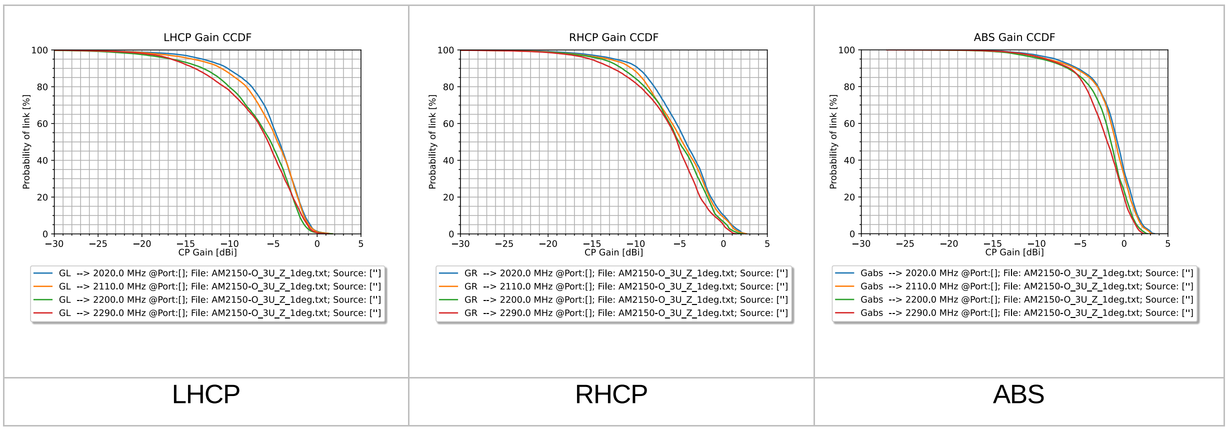


Figure 5-1. CCDF plots, AM2150-O on 3U +Z side.

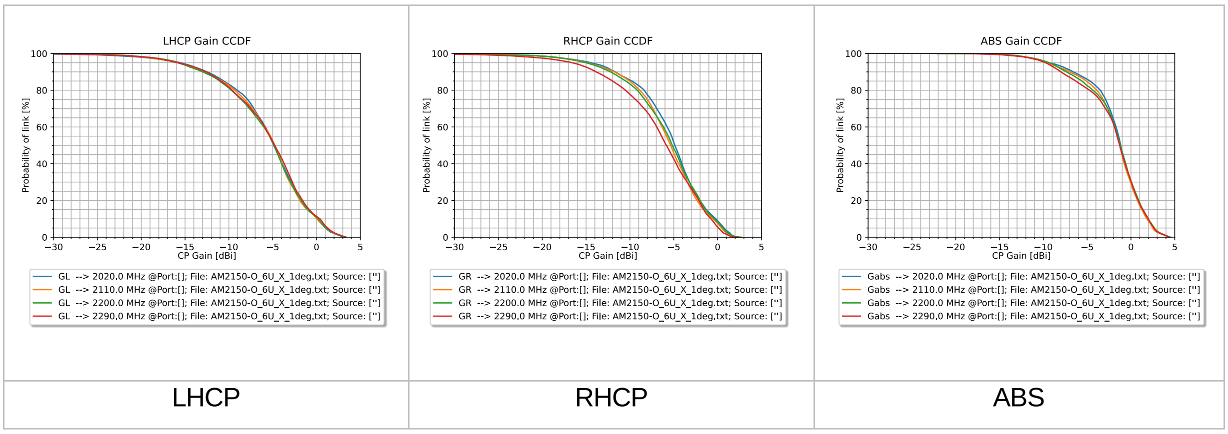
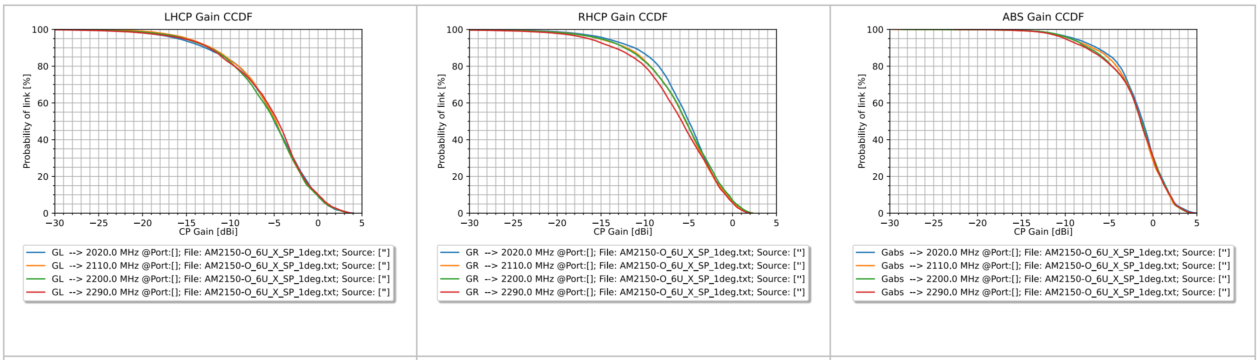


Figure 5-2. CCDF plots, AM2150-O on 6U +X side top quadrant.



LHCP	RHCP	ABS

Figure 5-3. CCDF plots, AM2150-O on 6U +X side top quadrant with deployable solar panel -X.

5.2 Simulation Model

The simulation model of the antenna is based on the 3DCAD of AM2150-O which is available from the GomSpace product WEB page under technical documents.

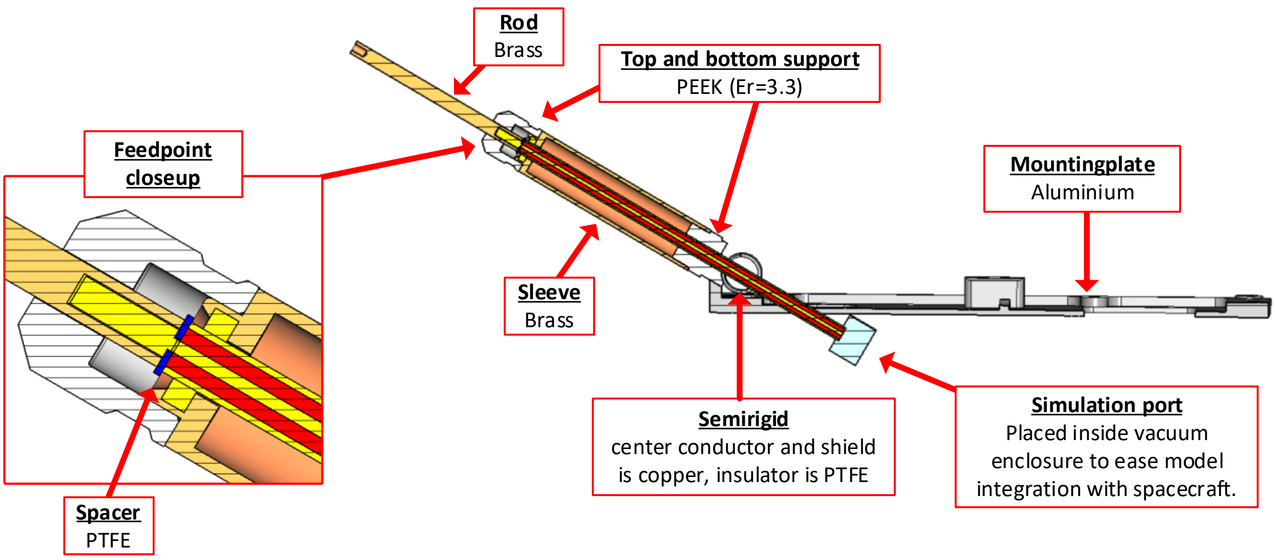


Figure 5-4. Simulation model overview and materials.

The semirigid used for feeding the antenna element has been extended and ends below the mounting plate where the actual feed is placed, to simplify the model. The feed is made as a discrete simulation port (CST Microwave terminology) from the centre conductor to the shield.

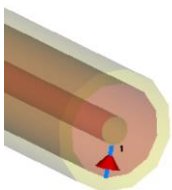


Figure 5-5. CST simulation port.

5.3 Directivity

The simulated directivity of the standalone antenna element resembles the pattern of a half wave dipole.

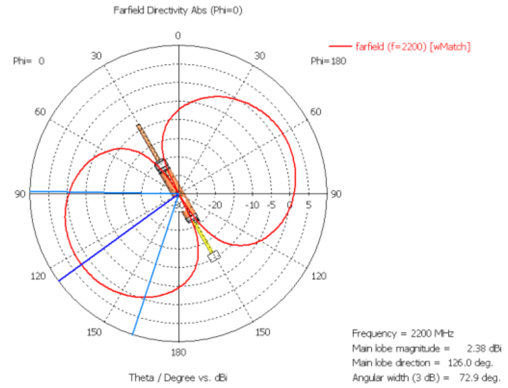


Figure 5-6. Simulated antenna element directivity at 2200MHz.

Once adding the back and mounting plates and attaching the antenna element onto a structure, the pattern gets distorted. Below are example directivity cuts on ABS gain for AM2150-O mounted on the +X to quadrant of a GomSpace 6U structure with a deployable solar panel in the -X direction.

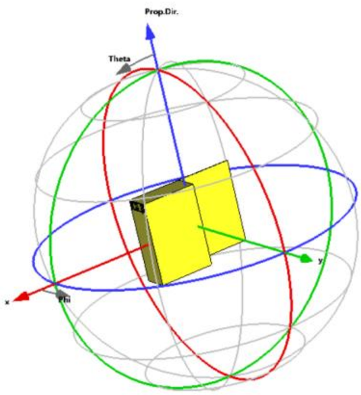
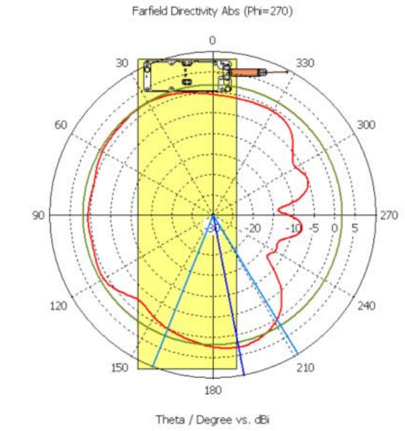
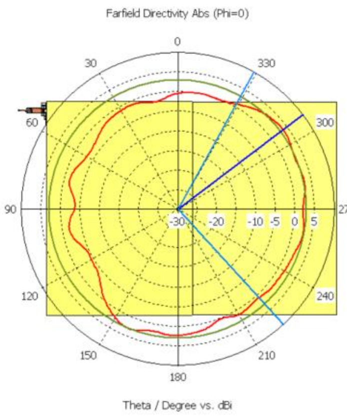
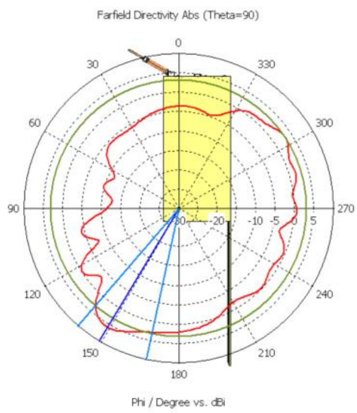
	
6U Simulation Model	YZ directivity cut
	
XZ Directivity Cut	XY Directivity Cut

Figure 5-7. Simulated directivity cuts at 2200MHz, AM2150-O on 6U +X and deployable solar panel -X.

5.4 Measured vs Simulated Radiation Pattern on 6U Structure

Realized antenna gain has been measured using a Satimo SG24 system and compared against simulation to validate the simulation model. AM2150-O was mounted on a mock-up to resemble a 6U structure with deployable solar panel.

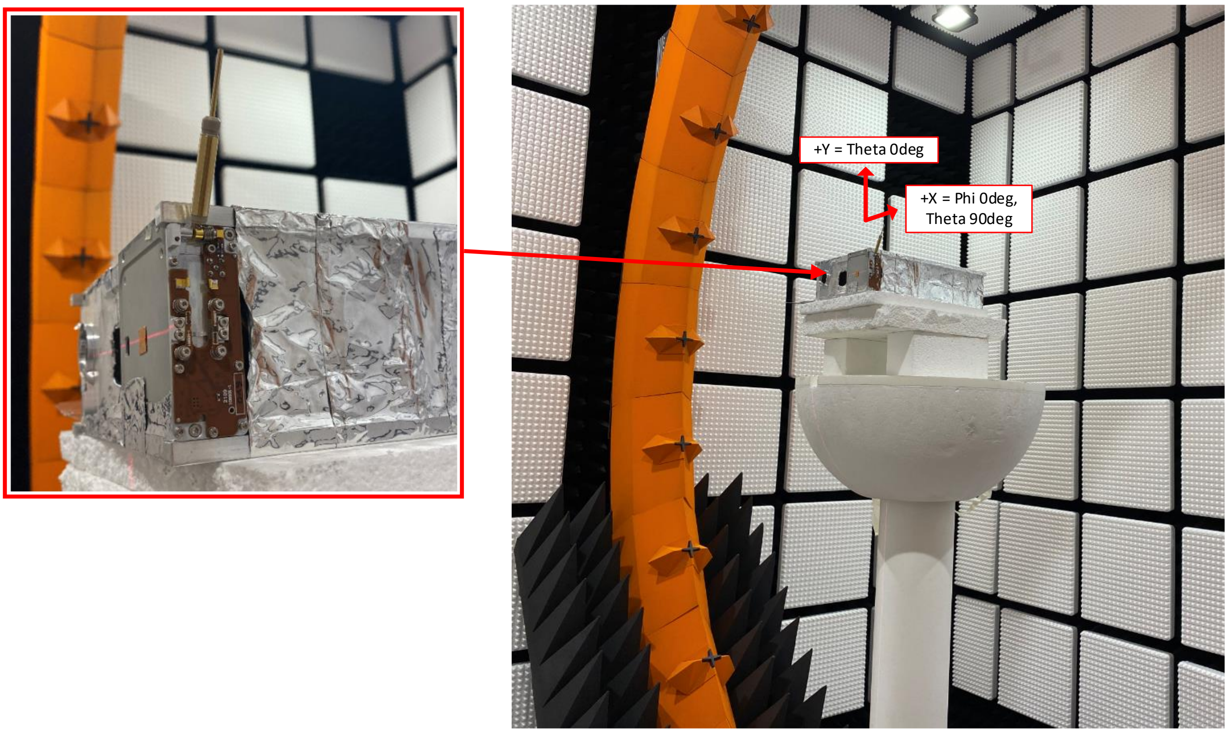


Figure 5-8. Satimo SG24 test setup.

The simulated and measured -12dBi coverage was found to be within 3% of each other.

Simulated vs Measured -12dBi Spherical Gain Coverage [%]						
Frequency	LHCP		RHCP		ABS	
	SIM	MEAS	SIM	MEAS	SIM	MEAS
2020MHz	90.0	88.5	89.6	91.4	97.6	98.2
2110MHz	91.0	89.4	89.4	90.3	97.7	98.2
2200MHz	91.3	89.1	88.5	89.5	98.1	98.5
2290MHz	91.9	88.9	84.0	86.8	98.6	97.9

Below is an example of the measured and simulated CCDF curves for LHCP and RHCP at 2200MHz on realized gain. Simulated curve is blue and measured is orange.

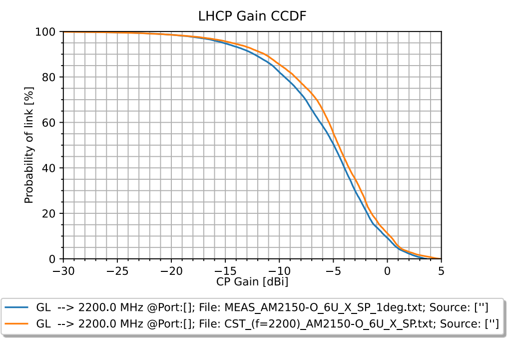


Figure 5-9. LHCP measured vs simulated CCDF on realized gain at 2200MHz.

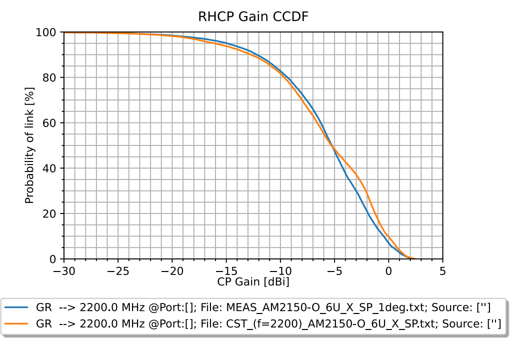


Figure 5-10. RHCP measured vs simulated CCDF on realized gain at 2200MHz.

6 Physical Characteristics

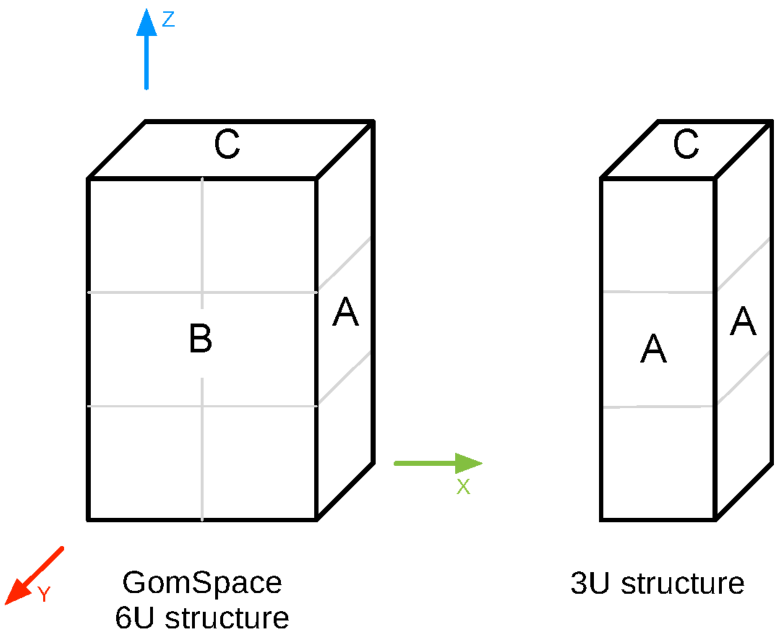
Parameter	Description	Conditions	Value	Unit
Size	Size depends on mounting options	See detail drawings		
Deployment angle	Deployment angle of the deployed antenna		150	°
Mass	Mass AM2150-O (No mounting plate)		24	g

7 Mounting and Combination with other GomSpace products.

7.1 Mounting Plate

Four different mounting plates are available, depending on where the antenna is placed on a nano-satellite. They are between 1.5-2 mm aluminium providing shielding from radiation. The mechanical sizes and holes position of each mounting plate is shown in chapter 10.
The option with no backplate can only be mounted on the A-side of the GomSpace 6U structure.

The 3U is used as an example; the plates can also be mounted on 1U and 2U nano-satellite.



7.2 Combination with other GomSpace Products.

The Type A, B and C backplate option have mounting options for several other GomSpace products. This is showcased in the matrix shown in Table 7-1. Note not all submodules can be mounted at the same time. This is communicated by letters where identical letters denote the submodules that can be mounted together. "N" denotes that it cannot be mounted together with the other submodules. Y1 denotes one configuration of mounting components on the backplate where Y2 denoted another configuration.
A picture of each submodule is found in chapter 11.

Submodules	X (A) backplate			Y (B) backplate			Z (C) backplate		
Tallysman GPS (Part of the GomSpace GPS-kit)	Y1	N	N	Y1	N	N	Y1	N	N
6U Flight preparation panel (FPP).	Y1	N	N	Y1	N	N	Y1	N	N
NanoUtil FPP Top-S	N	N	N	N	N	N	Y1	Y2	N
M315 with shield or M315 bracket	Y1	Y2	Y3	N	N	N	Y1	Y2	Y3
Programming and debugging port	N	N	Y3	N	N	Y3	N	Y2	N
Fine Sun Sensor	Y1	N	Y3	N	N	N	Y1	Y2	N
MSP-A-1-1 Solar panel	N	Y2	N	N	Y2	N	N	N	Y3

Table 7-1 Submodules mounting options

8 Antenna Release System

The antenna element is held down by a Dyneema monofilament wire (burnwire), which is connected to two independent burn resistors. The resistors are sequentially commanded to heat and melt the monofilament, releasing the antenna. The burnwire is located as shown in **Error! Reference source not found.** and as it is seen two clamps keeps the burnwire in position and ensures easy arming of the antenna.
Both the clamp system and the burn release system have flight heritage on several GomSpace products.

Further detail about arming and releasing the system is found in the manual for the product.

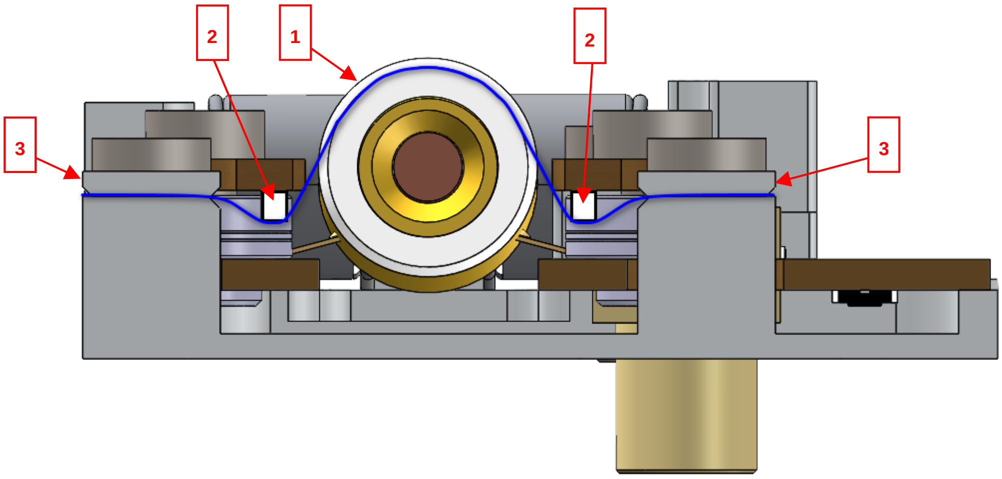


Figure 8-1 Burnwire position.

1. Burnwire
2. Burn resistor
3. Burnwire clamp

When the antenna is released, it will rotate to an angle of 30 degrees above the mounting plane.
The springs is tensioned below the safe rating in stowed mode, and it is thus safe to keep the antennas stowed indefinitely without effecting reliable deployment.

9 Environmental test

To simulate the harsh conditions of launch and space, the AM2150-O has been exposed to several environmental tests. Contact GomSpace for further information

10 Mechanical Drawing

All dimensions are in mm.

10.1 AM2150-O Type A in stowed configuration

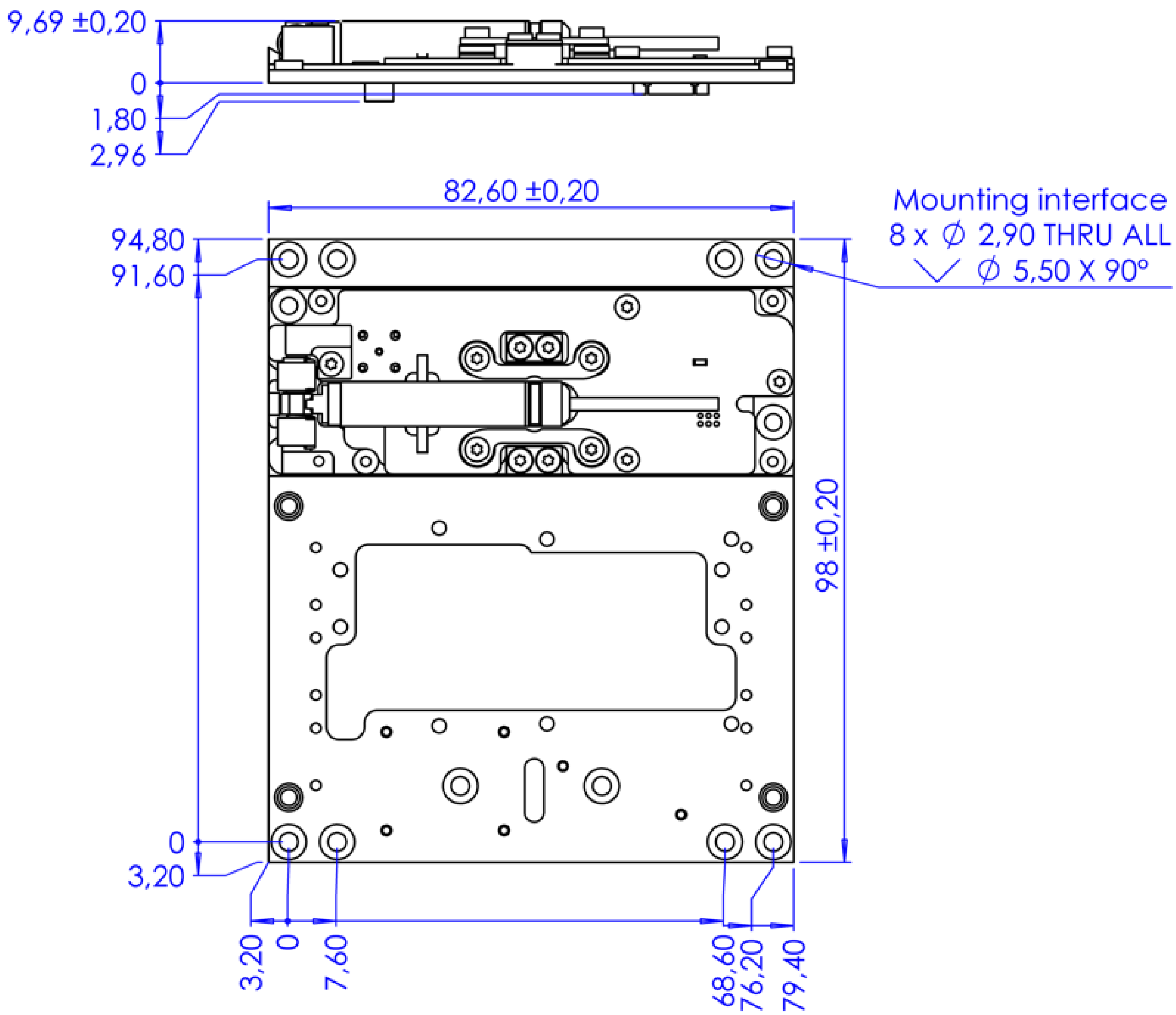


Figure 10-1 AM2150-O Type A in stowed configuration.

10.2 AM2150-O Type B in stowed configuration

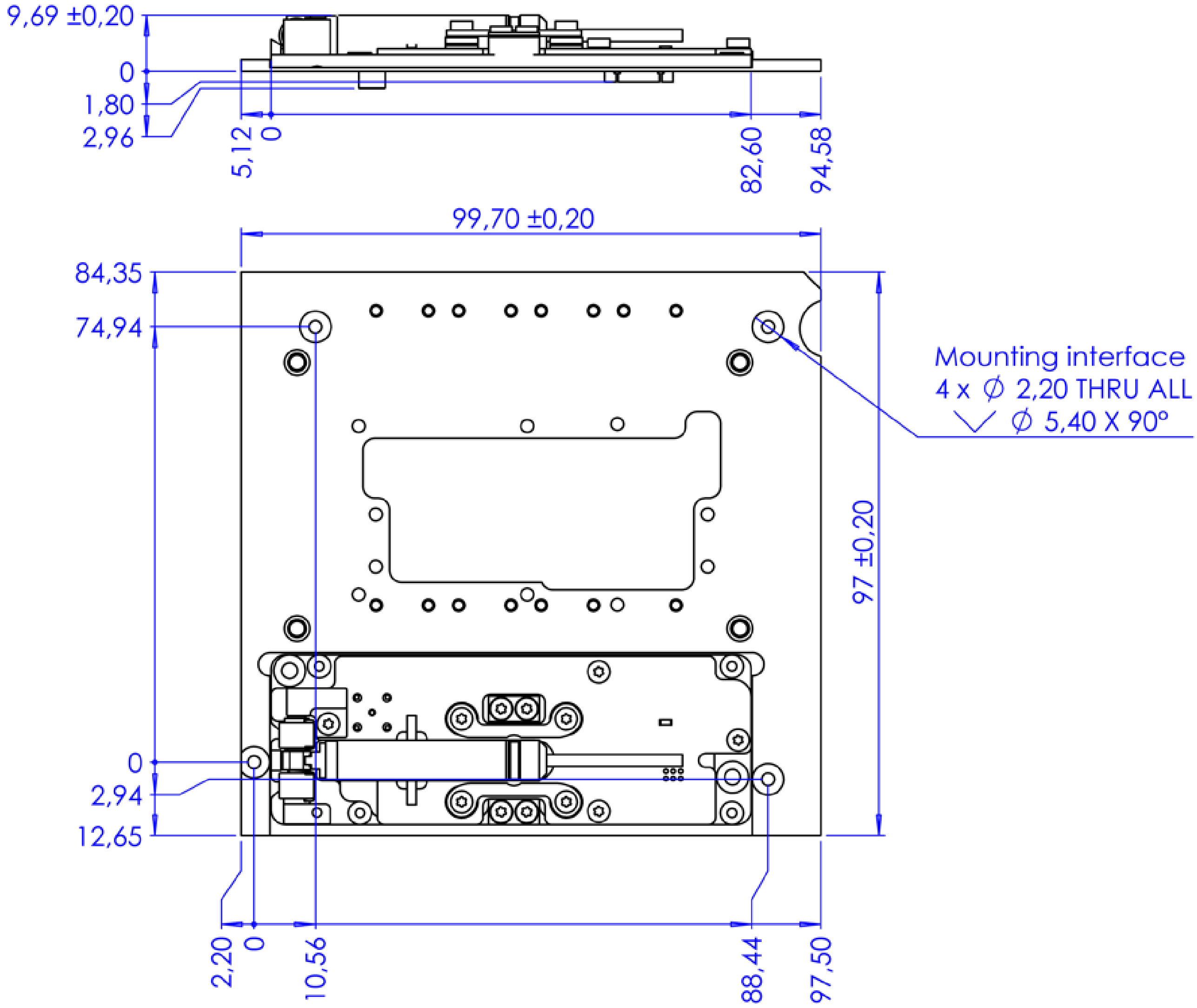


Figure 10-2 AM2150-O Type B in stowed configuration.

10.3 AM2150-O Type C in stowed configuration

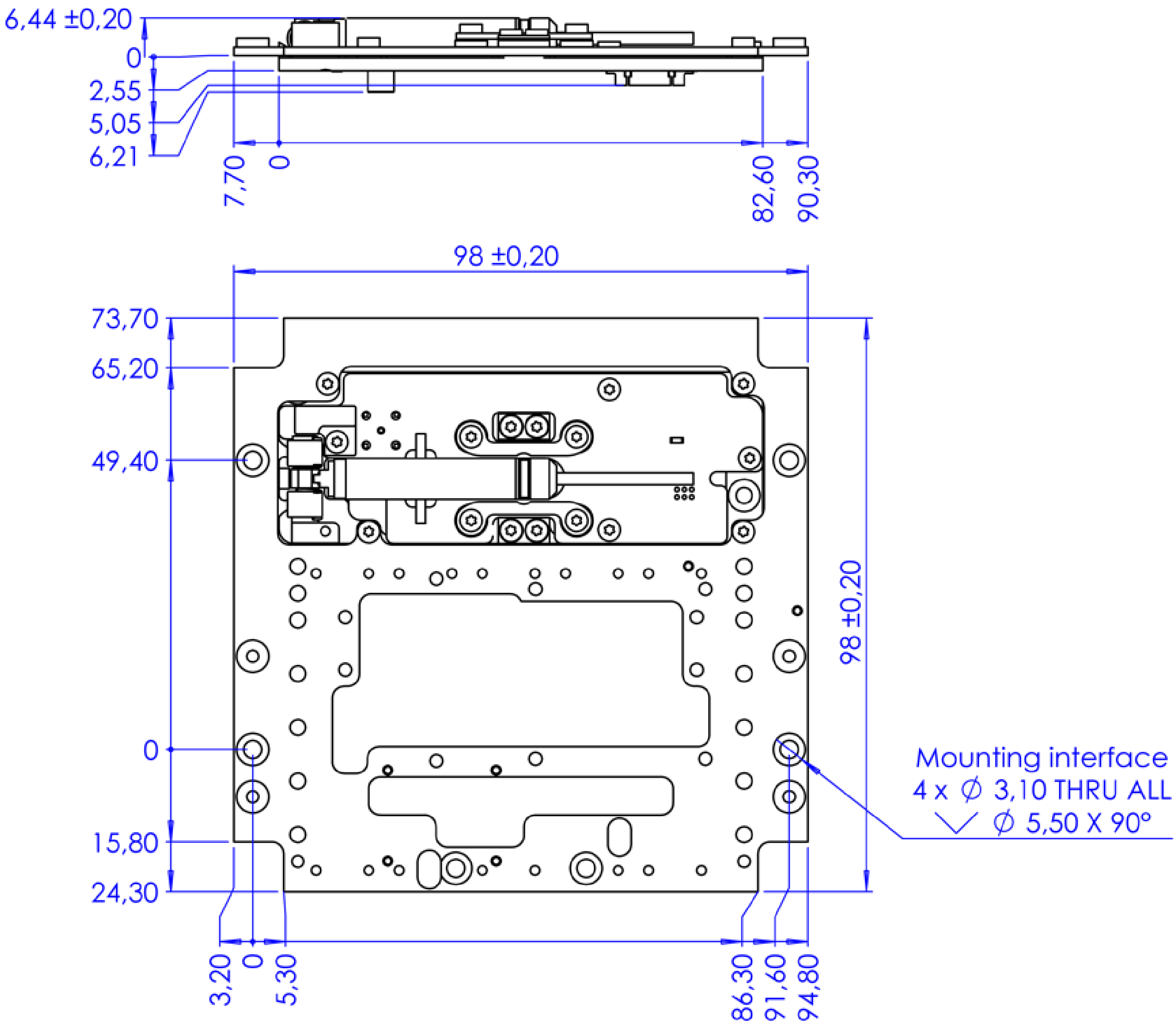


Figure 10-3 AM2150-O Type C in stowed configuration.

10.4 AM2150-O Type No plate in stowed configuration

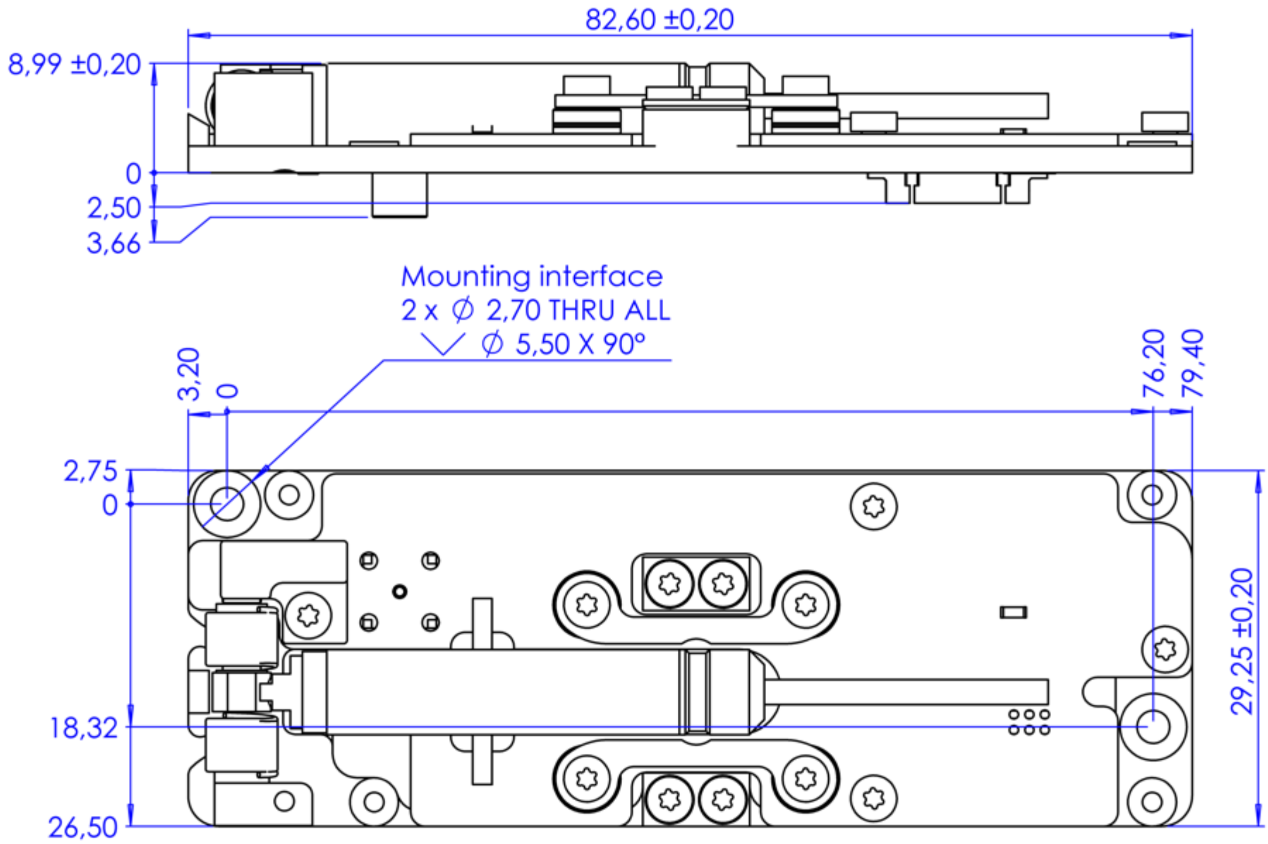
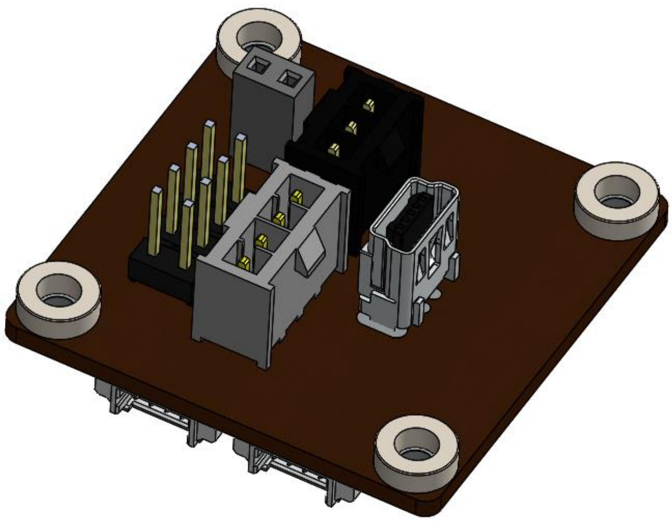


Figure 10-4 AM2150-O Type No plate in stowed configuration.

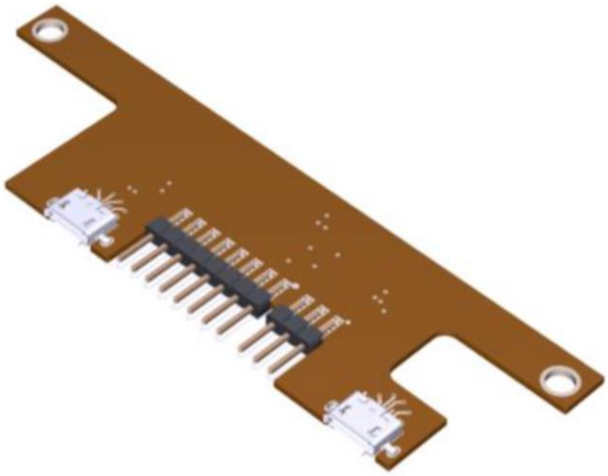
11 GomSpace Products from section 7.2

11.1 Tallysman GPS antenna

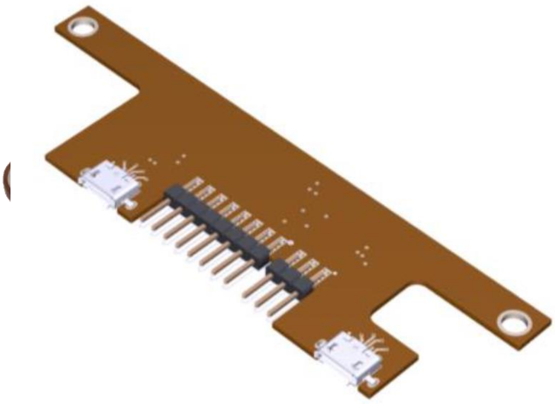
11.2 6U flight preparation panel



11.3 NanoUtil FPP Top-S

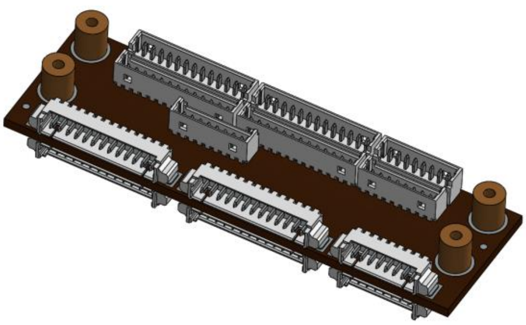


11.4 M315 with shield or M315 bracket



Illustrated without a shield

11.5 Programming and debugging port



11.6 Fine sun sensor

11.7 MSP-A-1-1 Solar panel

12 Disclaimer

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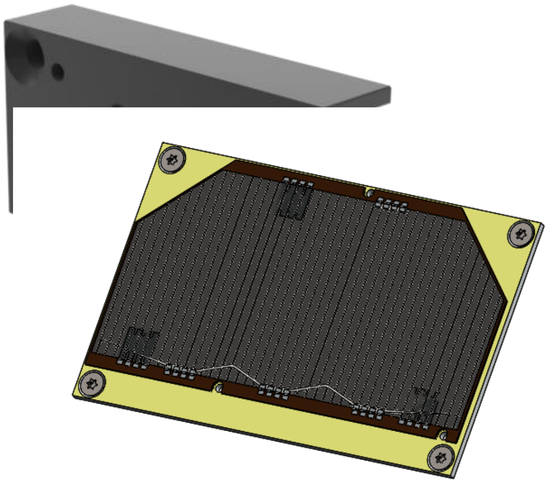

or the software and hardware described in this document.