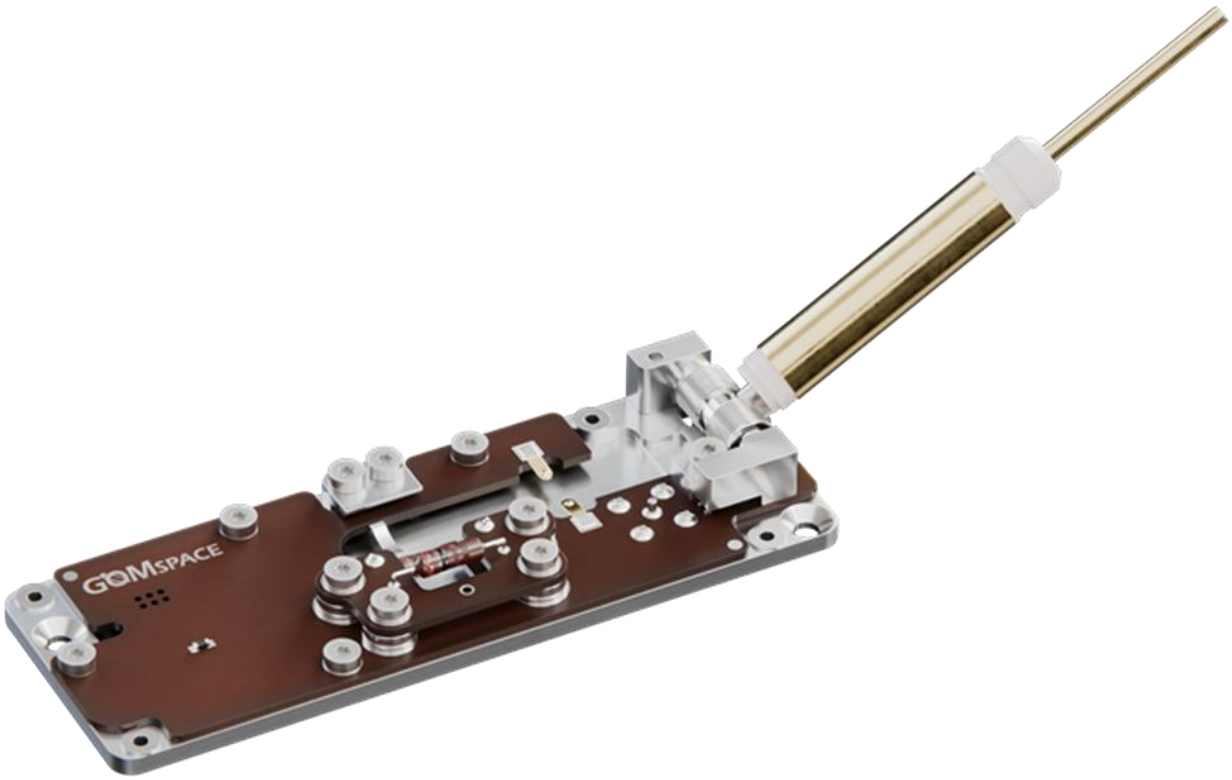

NanoCom
AM2150-O MK2 Antenna System

Datasheet

GomSpace A/S | Langagervej 6 | DK-9220 Aalborg East | Denmark
gomspace.com | sales@gomspace.com | T: +45 71 741 741

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Author: ROBB

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Table of Contents

1 Overview

The NanoCom AM2150-O MK2 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 MK2 supports a range of structure sizes, including 1U, 2U, 3U, 6U, and 12U, enabling flexible installation of the antenna system across various 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 MK2, 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 provide multiple interface options for integration with other GomSpace products, including GPS antenna, the Flight Preparation Panel, and the Fine Sun Sensor, among others
- Compatible with AR6 antenna release functionality embedded in GomSpace NanoPower P60 (AM2150-O MK2 5V option) and P80 (AM2150-O MK2 32V option)

1.2 Functional Description

AM2150-O MK2 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.

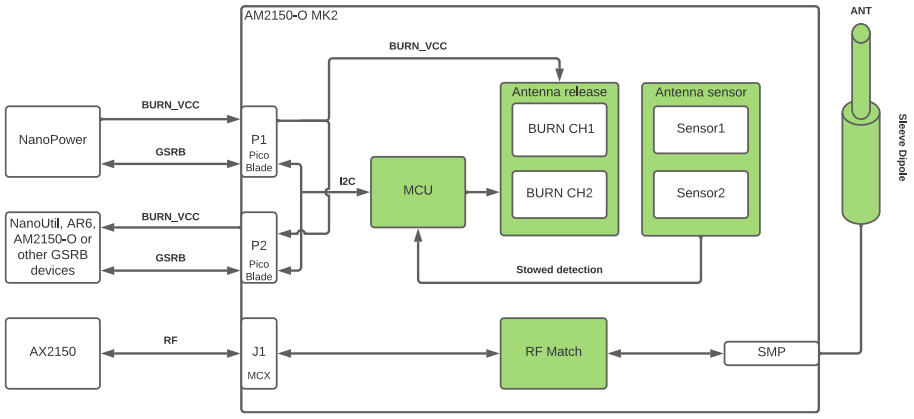


Figure 1-1. AM2150-O MK2 Block Diagram

The antenna element is fixated in stowed position by a Dyneema monofilament line. The line is routed across the housing of two axial metal film resistors on one side of the antenna element. Each resistor has an associated burn channel. A curvature on the middle part of the antenna element assembly, keeps the line into place. The line is fixated by a clamp on the other side of the antenna element.

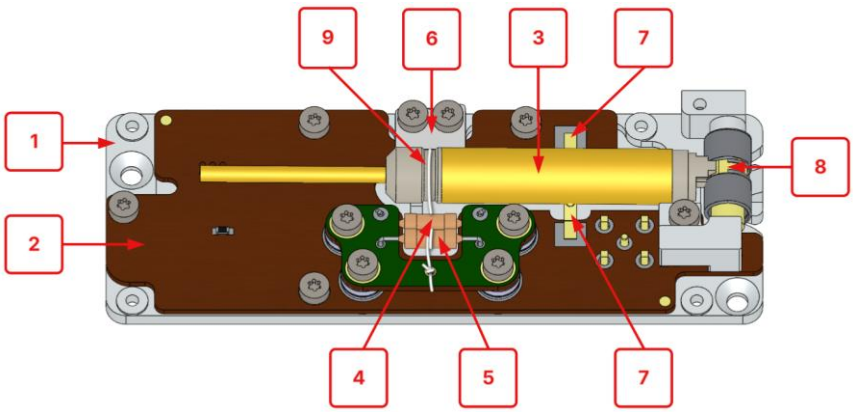


Figure 1-2. AM2150-O MK2 3DCAD Stowed

1. Mounting Plate
2. Main Board
3. Antenna Element
4. BURN CH1
5. BURN CH2
6. Burnwire Clamp
7. Sensor 1 & Sensor 2
8. SMP based spring loaded hinge
9. 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 fourteen releases per burn resistor to test antenna release during assembly, integration and verification of the spacecraft.

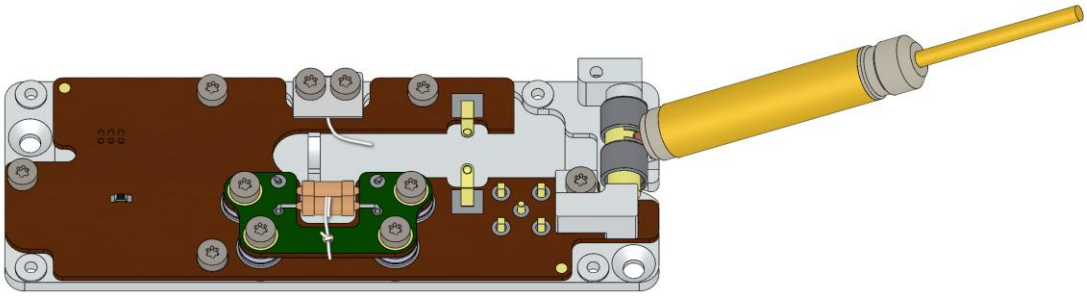


Figure 1-3. AM2150-O MK2 3DCAD Deployed

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 MK2 is not included and will have to be provided externally.

1.3 Application Example

An example of the total radiated field with AM2150-O MK2 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.

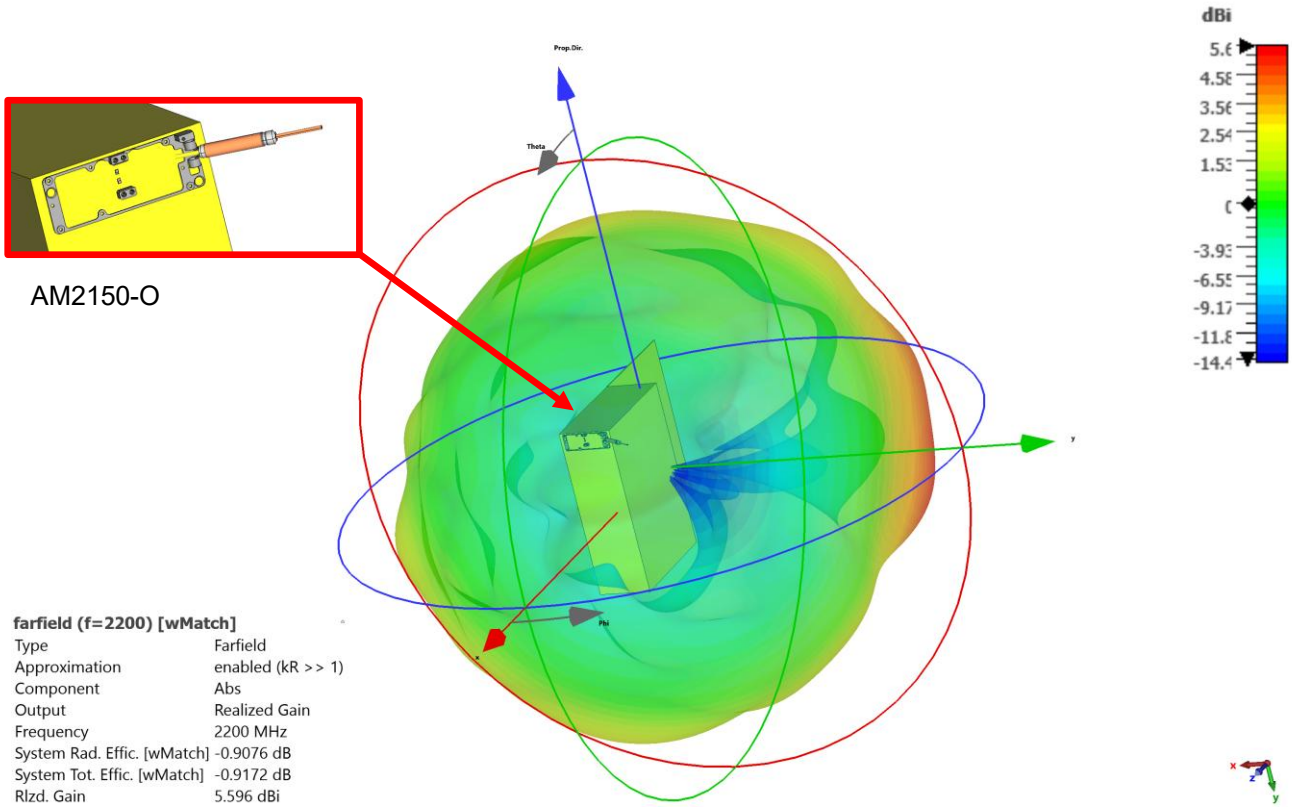


Figure 1-4. AM2150-O ABS radiation pattern at 2200MHz, on 6U with deployable solar panel.

2 Hardware Layout, Connectors

The bottom side of the AM2150-O MK2 contains the GSRB and RF interface connectors.

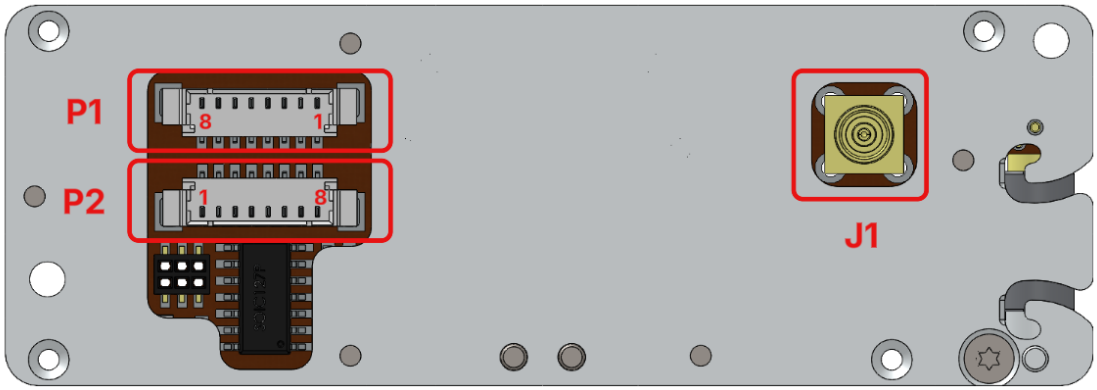


Figure 2-1. AM2150-O MK2 bottom side view.

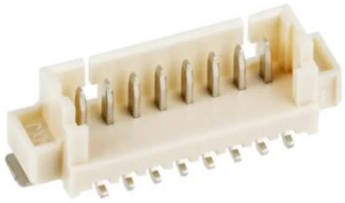
P1 and P2	J1
Molex 53398-0871 8pin 1.25mm pitch PicoBlade Header.	Samtec MCX-J-P-H-ST-TH1 50ohm MCX jack, female socket.
	

Figure 2-2. Connectors.

2.1 P1 – GSRB BUS

GomSpace release bus connector P1.

Pin	Name	Description
1	GSRB_SDA	MCU I^2C Data
2	GSRB_SCL	MCU I^2C 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

2.2 P2 – GSRB BUS

GomSpace release bus connector P2.

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

2.3 J1 - Antenna

50 ohm MCX connector.

Pin	Description
Centre	Inner conductor / RF signal pin
Sleeve	Outer Shield / RF ground

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

2.4 Antenna and GSRB BUS Grounding

The back plate and thereby the exterior of the spacecraft serves as the reference ground for the antenna. BURN_GND and GSRB_GND nets are separated from the reference ground by a 4k7ohm resistor to reduce unintentional current paths between the release system and the exterior of the spacecraft.

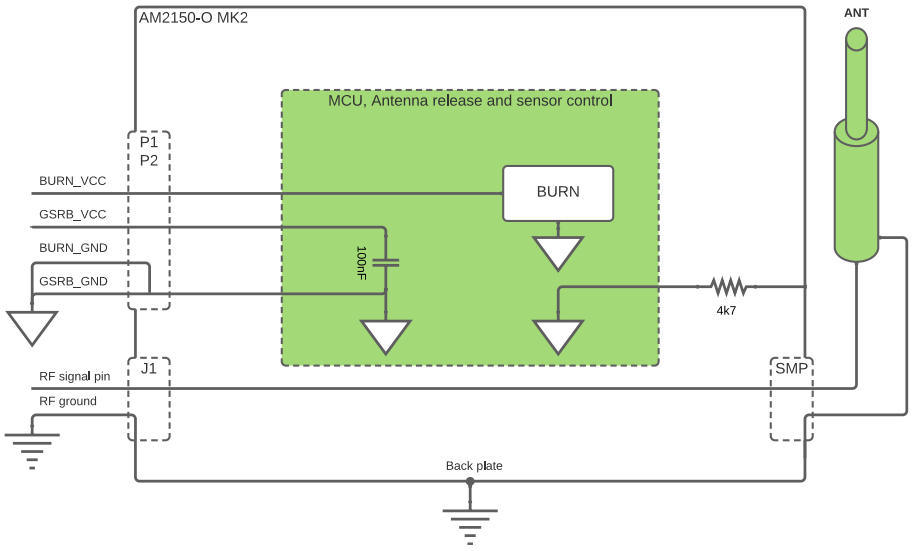


Figure 2-3. Antenna and GSRB BUS grounding.

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
$B_{duration}$[1]	Maximum burn time duration		30	Sec
B_{num}[1]	Number of activations times each burn resistor		15	

1) Exceeding the maximum burn time duration and activation times will degrade the lifetime and reliability of the burn resistors. The maximum burn duration is pre-configured to 30sec 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

The 5V option is compliant with a regulated VBURN voltage. This option is compatible with the GomSpace Sensor / Release Bus interface embedded in NanoPower P60 and exposed on P6 of the Dock.

The 32V option is compliant with an unregulated VBURN voltage. This option is compatible with the GomSpace Sensor / Release Bus interface embedded in NanoPower P80 and exposed on J3 and J4 of the PMU.

For further information on how to release the antenna based on the AR6 release functionality integrated into the NanoPower P60 Dock or NanoPower P80 PMU refer to the AM2150-O MK2 Manual.

Symbol	Description	Min	Typ	Max	Unit
VCC	GSRB Supply Voltage	3.0	3.3	3.6	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	400	500	600	mA
$5V_{TBURN}$[1]	Antenna release time 5V option		7	30	Sec
$32V_{VBURN}$	VBURN supply voltage 32V option	24	28.8	33.6	V
$32V_{IBURN}$	VBURN supply current 32V option	60	100	400	mA
$32V_{TBURN}$[1]	Antenna release time 32V option		5	30	Sec
SCL_{speed}	I^2C standard and fast mode are supported			400	kHz

1) Typical and max burn duration required to release antenna at 1atm pressure across supported VBURN and operating temperature ranges. At 0atm pressure burn time decreases by up to 1.0 sec.

4.1 Typical Burn Time 5V option

Typical burn times for the 5V option are listed below, covering nominal and extreme VBURN and ambient temperature at 1atm pressure.

VBURN	Ambient Temperature			Unit
	-40°C	25°C	85°C	
4.5V	22			Sec
5.0V		7		Sec
5.5V			3	Sec

4.2 Typical Burn Time 32V option

Typical burn times for the 32V option are listed below, covering nominal and extreme VBURN and ambient temperature at 1atm pressure.

VBURN	Ambient Temperature			Unit
	-40°C	25°C	85°C	
24.0V	18			Sec
28.8V		5		Sec
33.6V			2	Sec

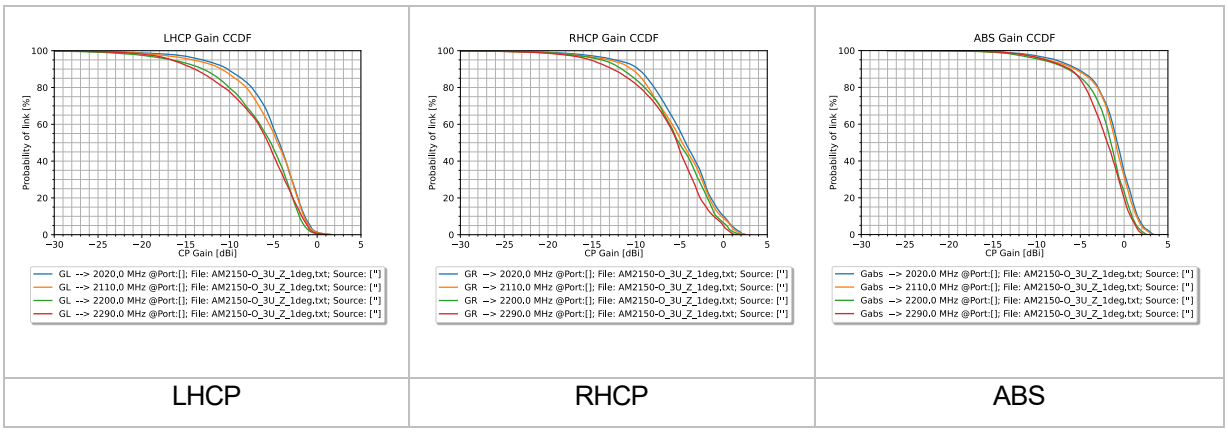
5 RF Characteristics

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
$G_{a,sys}$	AM2150-O MK2 antenna gain on 3U or 6U Structure	> -12 dBi	80	% of directions

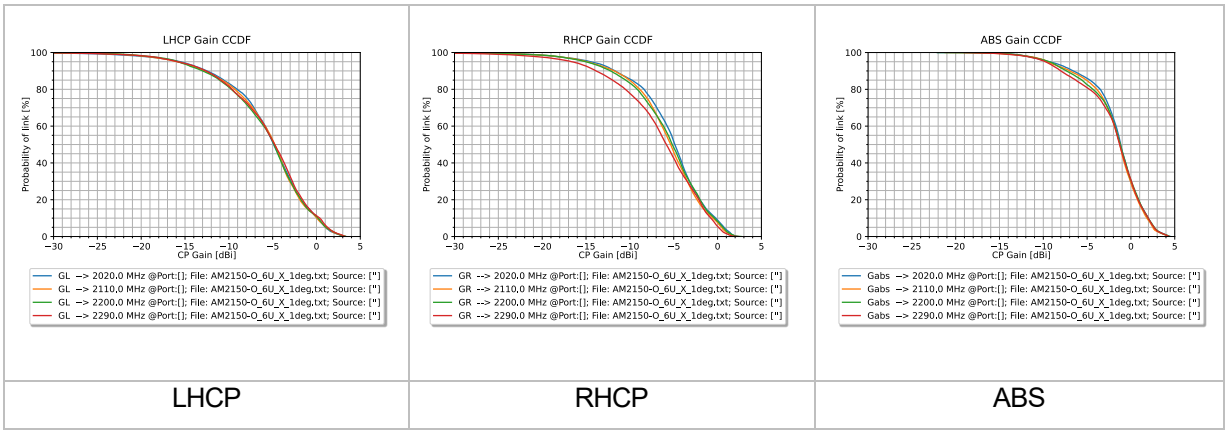
5.1 CCDF Plots

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.



LHCP	RHCP	ABS

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



LHCP	RHCP	ABS

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

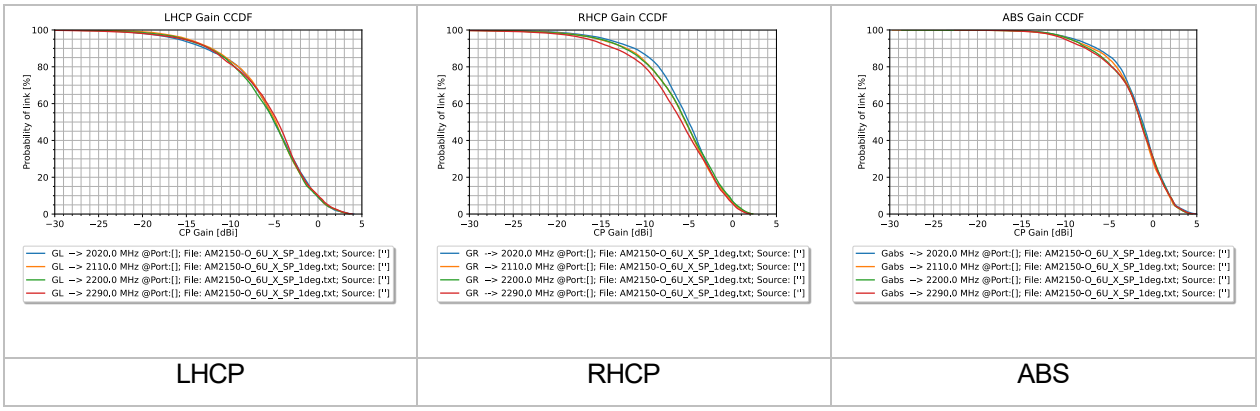


Figure 5-3. CCDF plots, AM2150-O on 6U +X side top quadrant with deployable solar panel -X.

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.

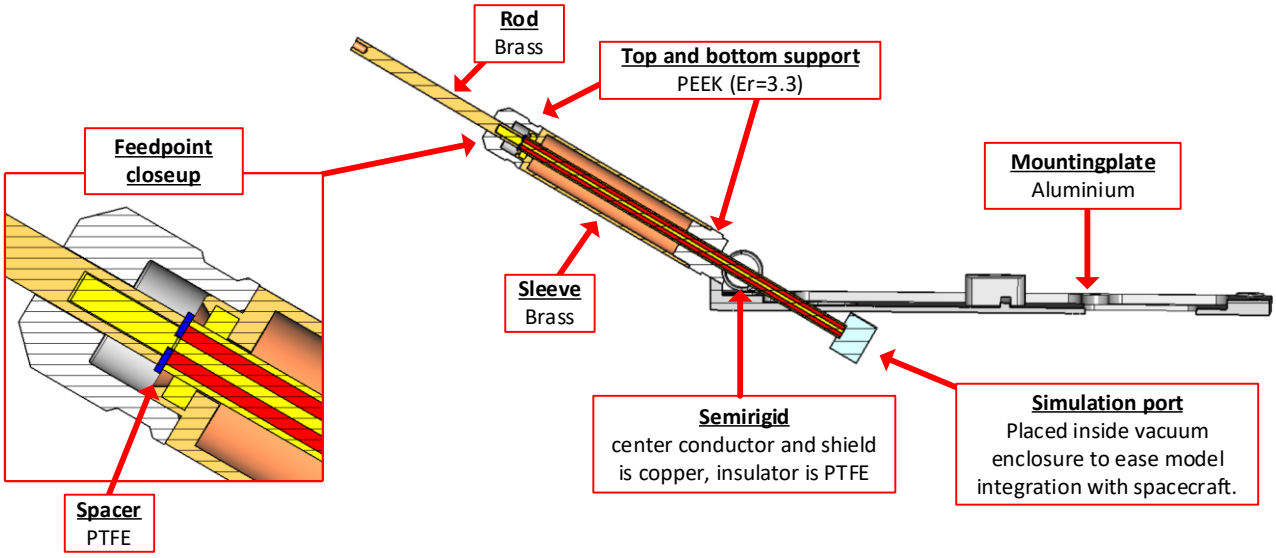


Figure 5-4. Simulation model overview and materials.

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.

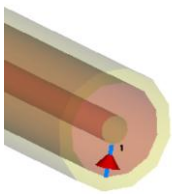


Figure 5-5. CST simulation port.

5.3 Directivity

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

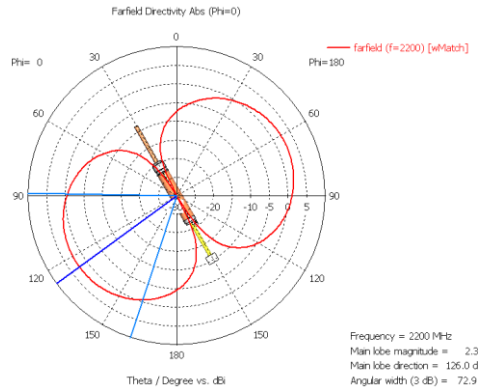


Figure 5-6. Simulated antenna element directivity at 2200MHz.

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.

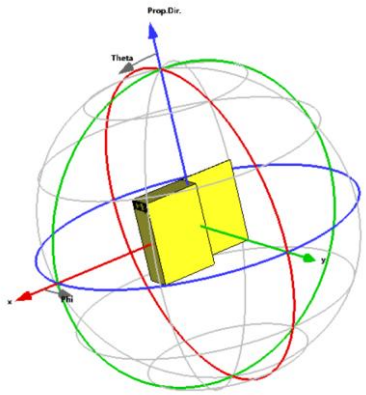
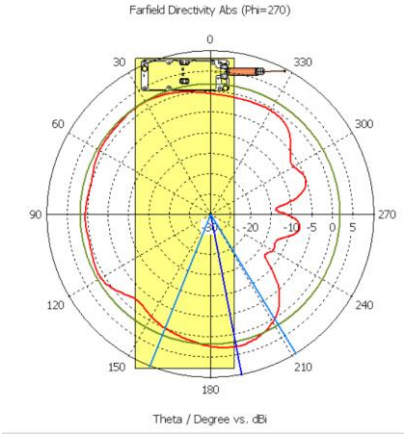
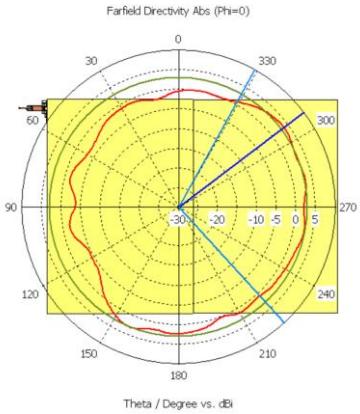
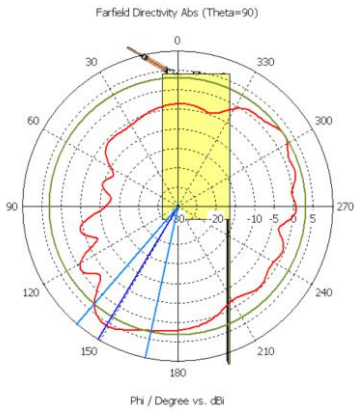
<table>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>6U Simulation Model</td><td>YZ directivity cut</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>XZ Directivity Cut</td><td>XY Directivity Cut</td></tr>
</table>

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.

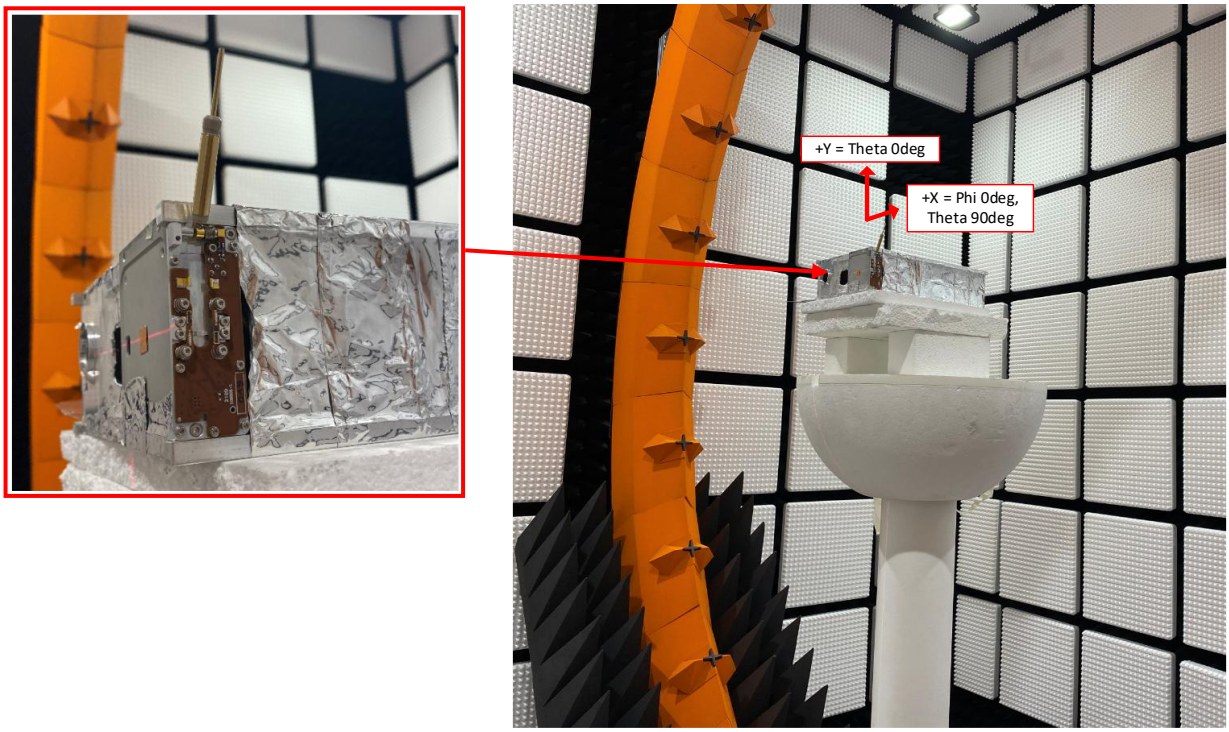


Figure 5-8. Satimo SG24 test setup.

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.

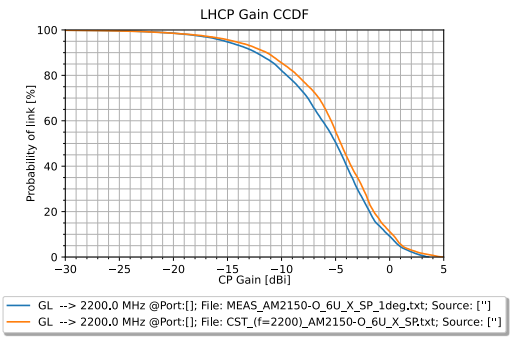


Figure 5-9. LHCP measured vs simulated CCDF on realized gain at 2200MHz.

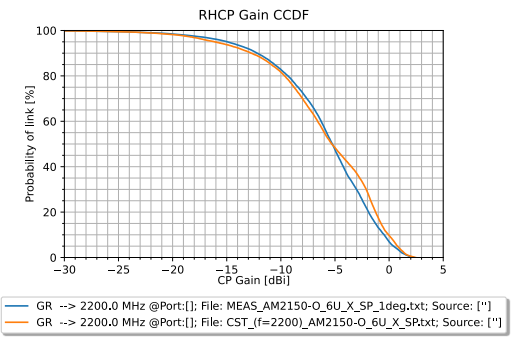


Figure 5-10. RHCP measured vs simulated CCDF on realized gain at 2200MHz.

6 Physical Characteristics

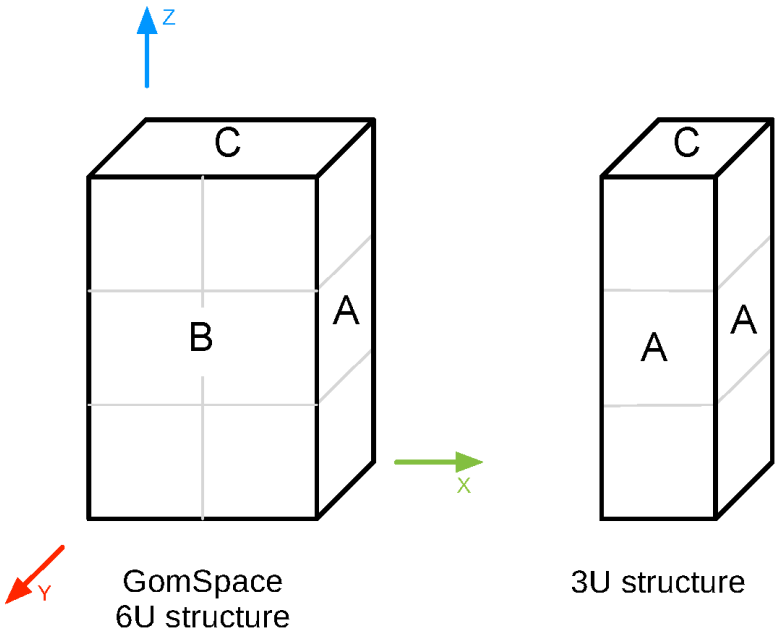
Parameter	Description	Conditions	Value	Unit
Size	Size depends on mounting options	See detail drawings		
Deployment angle	Deployment angle of the deployed antenna		150	°
Mass	Mass AM2150-O MK2 (No mounting plate)		23.5 ±1	g

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. The mounting plates are made of 1.5-2 mm thick aluminium providing shielding from radiation. The mechanical size and mounting hole positions are shown in chapter 10 for each mounting plate.
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 illustrated in the matrix presented in Table 7-1. Note not all submodules can be mounted at the same time. This is indicated by letters, where matching letters identify submodules that can be mounted together. “N” indicates that the submodule cannot be mounted together with other submodules. “Y1” represents one mounting configuration on the backplate, “Y2” represents another, and so on.
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. A single clamp fixates the burnwire once the antenna element is stowed and ensures easy arming of the antenna. The burnwire is located as shown in Figure 8-1.

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

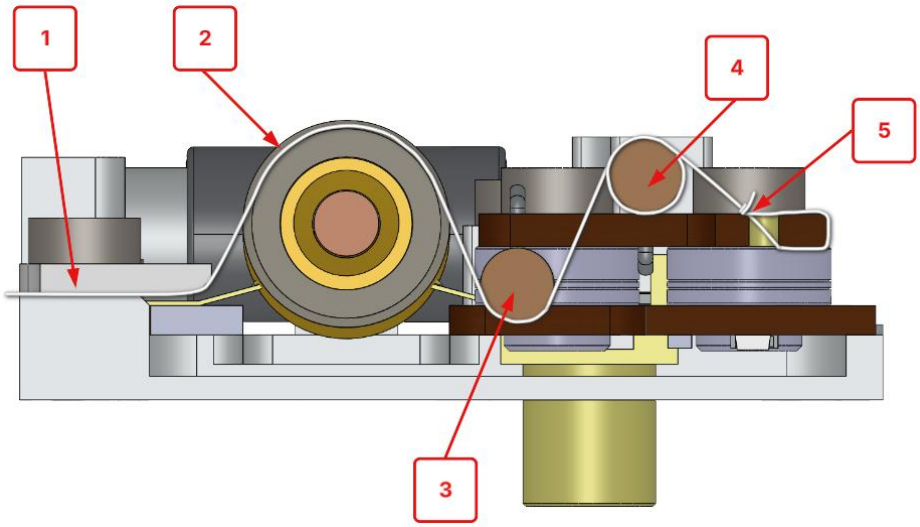


Figure 8-1 Burnwire position.

1. Burnwire clamp
2. Burnwire
3. Burn resistor 1 (burnwire makes a half turn around the lower part of resistor 1 body)
4. Burn resistor 2 (burnwire makes one full turn around resistor 2 body)
5. Knot fixating burnwire to resistor PCB

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 MK2 has been exposed to several environmental tests. Contact GomSpace for further information

10 Mechanical Drawing

All dimensions are in mm.

10.1 AM2150-O MK2 Type A in stowed configuration

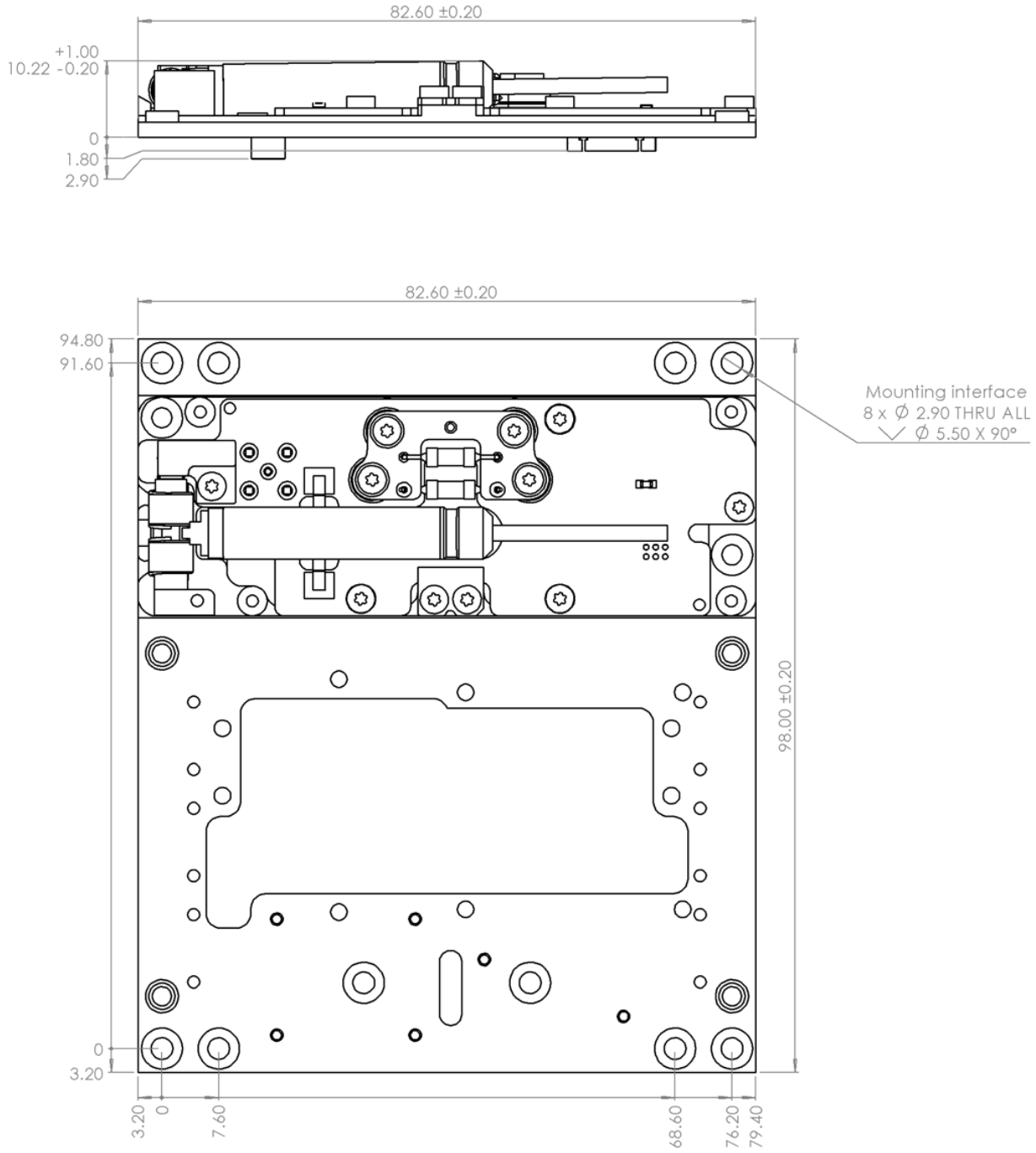


Figure 10-1 AM2150-O MK2 Type A in stowed configuration.

10.2 AM2150-O MK2 Type B in stowed configuration

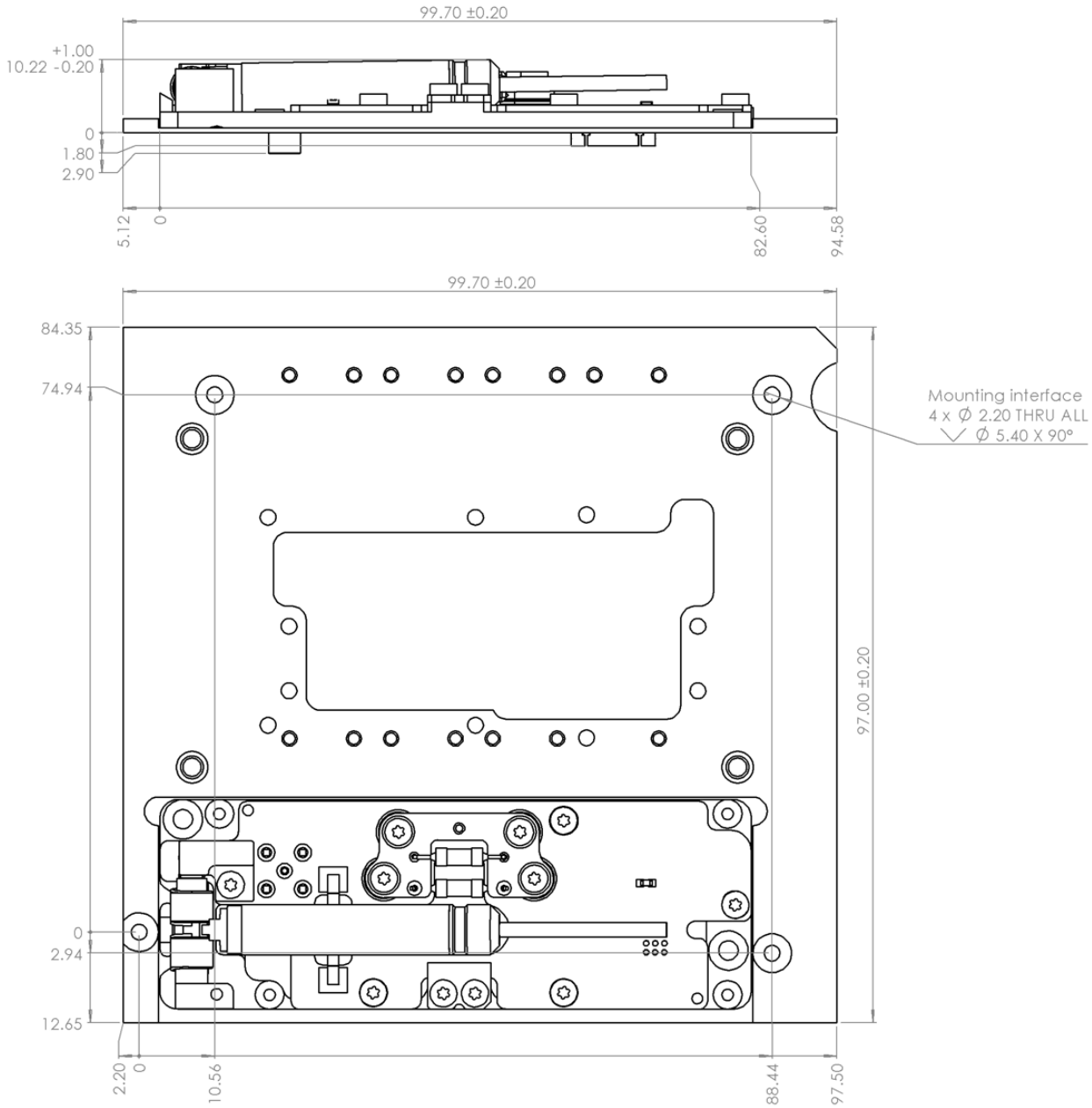


Figure 10-2 AM2150-O MK2 Type B in stowed configuration.

10.3 AM2150-O MK2 Type C in stowed configuration

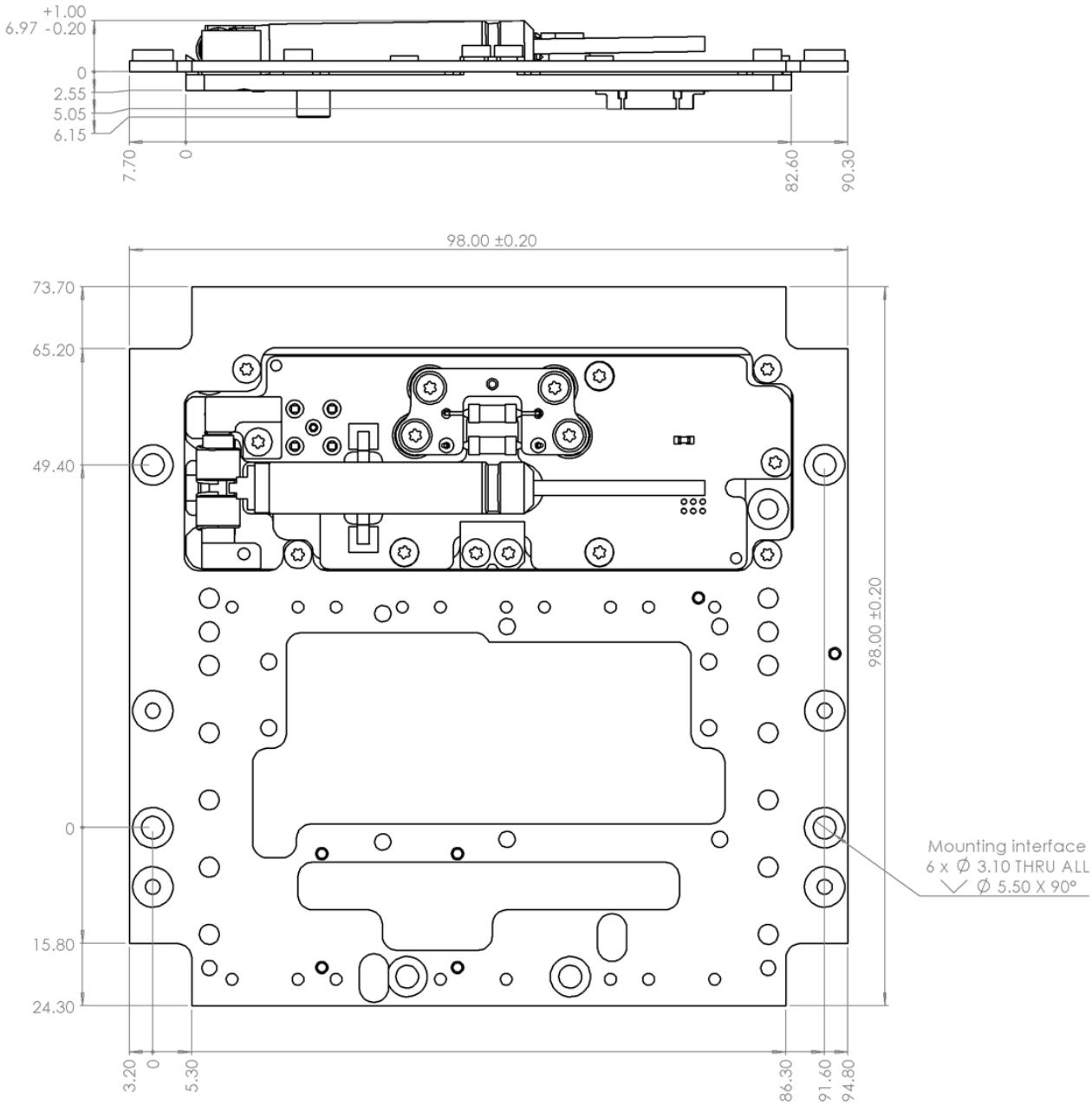


Figure 10-3 AM2150-O MK2 Type C in stowed configuration.

10.4 AM2150-O MK2 Type No plate in stowed configuration

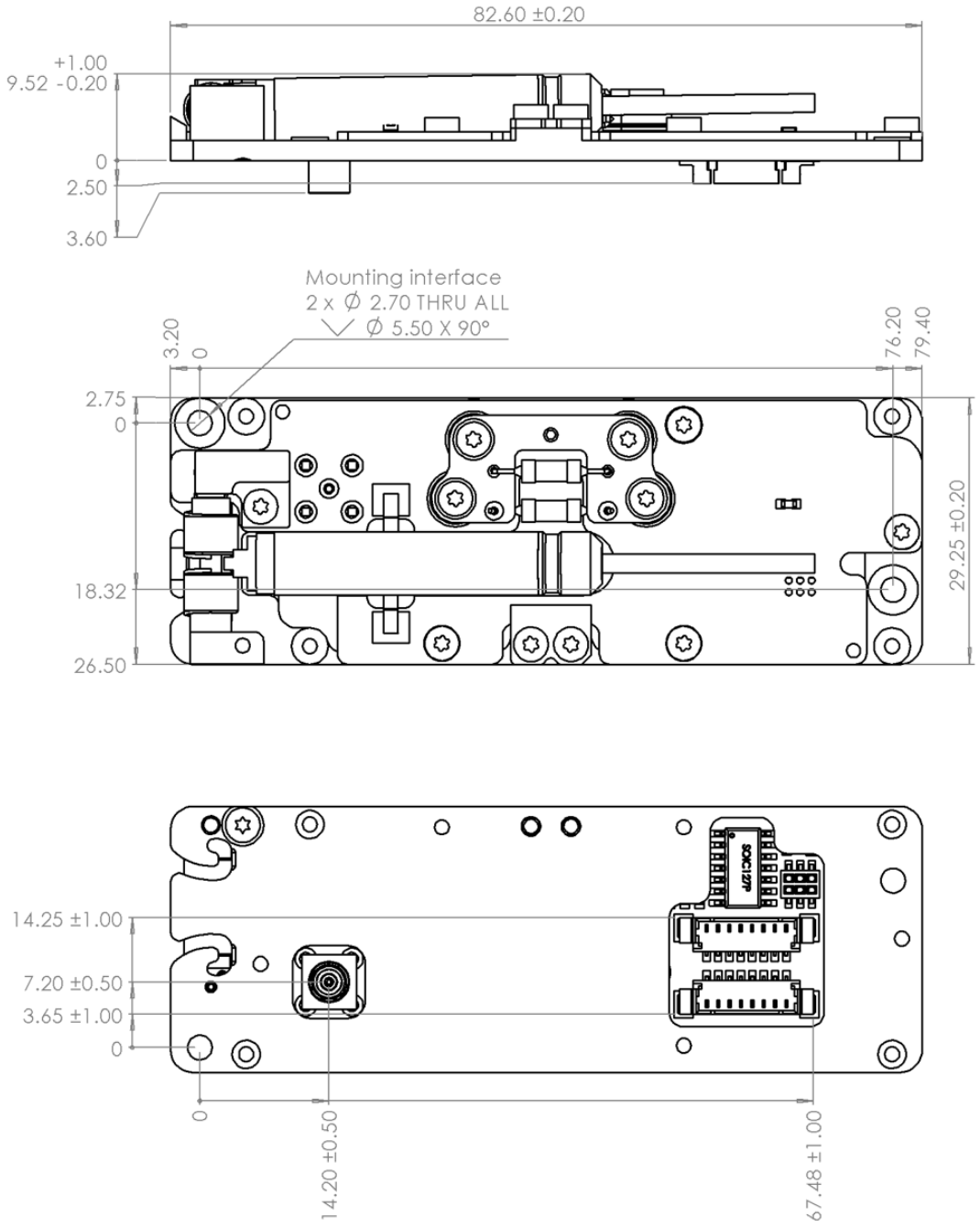
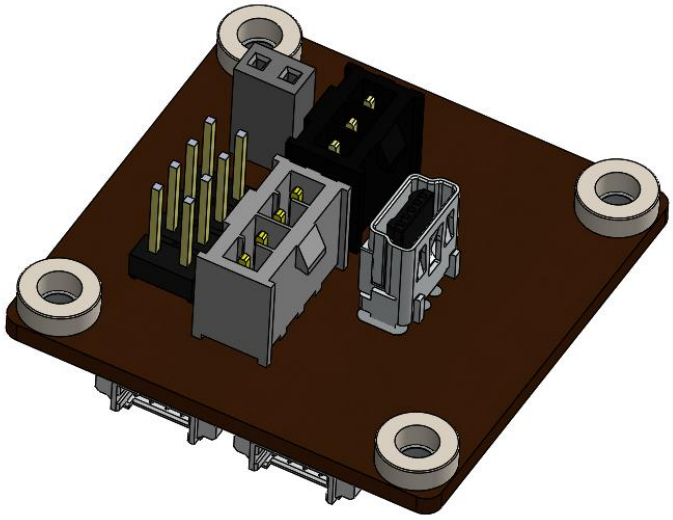


Figure 10-4 AM2150-O MK2 Type No plate in stowed configuration.

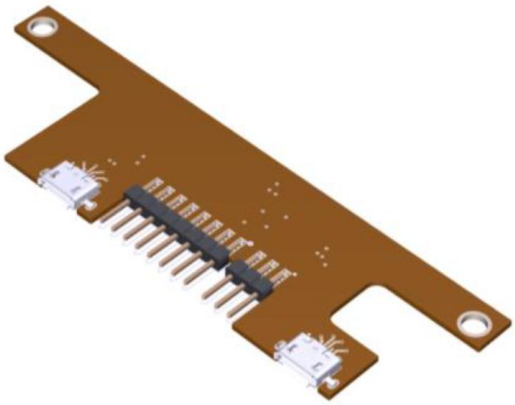
11 GomSpace Products from section 7.2

11.1 Tallysman GPS antenna

11.2 6U flight preparation panel

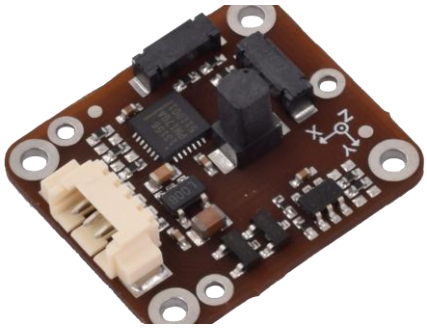


11.3 NanoUtil FPP Top-S

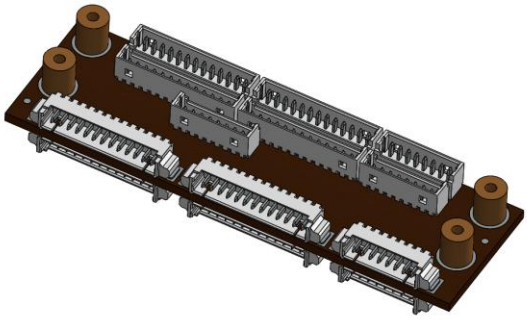


11.4 M315 with shield or M315 bracket

Illustrated without a shield



11.5 Programming and debugging port



11.6 Fine sun sensor

11.7 MSP-A-1-1 Solar panel