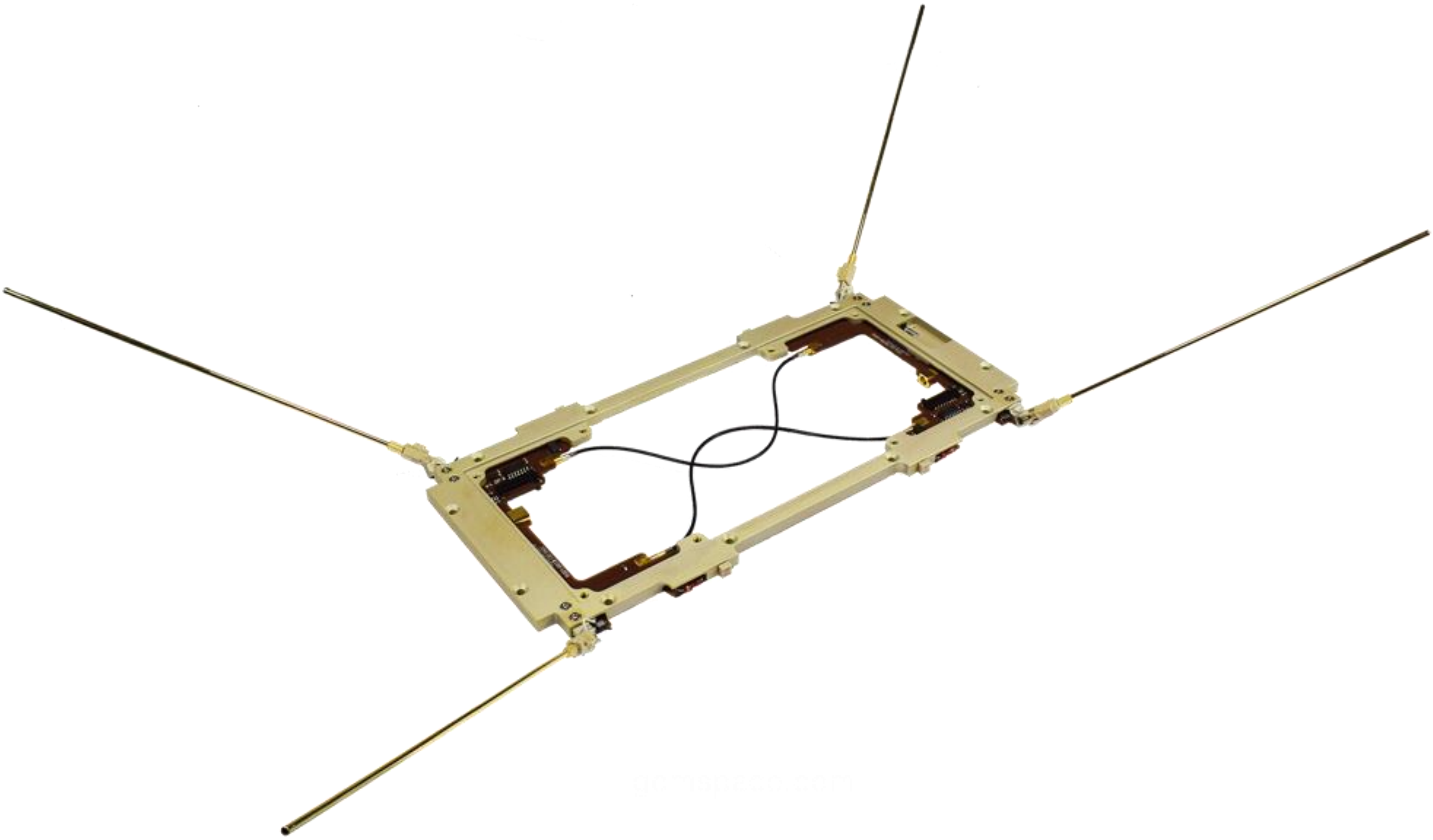

NanoCom
Ant-6f UHF

Datasheet

UHF antenna for GomSpace 6U structure

Product name: **NanoCom ANT-6F UHF**

Document No.: **1010785**

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Handling Precautions

The electronic circuits include static sensitive devices. To mitigate ESD from damaging the circuits, use proper grounding when handling.

Table of Contents

1 OVERVIEW 4
1.1 Highlighted Features 5
1.2 Block Diagram 6

2 MODE OF OPERATION 7
2.1 Mode 1 8
2.2 Mode 2 8
2.3 Mode 3 9

3 ANTENNA DEPLOYMENT 9
3.1 Active Antenna Deployment 9
3.2 Antenna Stowing Procedure 10

4 HARDWARE LAYOUT, CONNECTORS AND PIN OUT 11
4.1 ANT-6F UHF Top 11
4.1.1 P1 – External Programmer 11
4.1.2 P2 – GomSpace Release Bus (GSRB) Connector 11
4.2 ANT-6F UHF Bottom 12
4.2.1 P3 – GomSpace Release Bus (GSRB) Connector 12
4.2.2 J5 - MCX RF Connector 13
4.2.3 J3/J4 - SMPM RF Connector 13
4.3 Connection to the Antenna Rods 13

5 DATA INTERFACE – ANTENNA DEPLOYMENT 13

6 ABSOLUTE MAXIMUM RATINGS 14

7 ELECTRICAL CHARACTERISTICS 14

8 RF PERFORMANCE CHARACTERISTICS 14

9 PHYSICAL CHARACTERISTICS 14

10 ANTENNA PERFORMANCE 15
10.1 Antenna Radiation 15
10.2 Radiation Pattern 15
10.3 Absolute Gain Probability 19
10.4 Dual Port Usage Caution – Input port Isolation 20

11 TOP LAYER MODULARITY 21

12 FREQUENCY VARIANTS 22

13 ENVIRONMENTAL TEST 22

14 INTEGRATION 22

15 APPLICATION NOTES 23
15.1 Antenna-Receiver Diversity Setup 23
15.2 Redundant Radios 23
15.3 GomSpace Ground Support 23

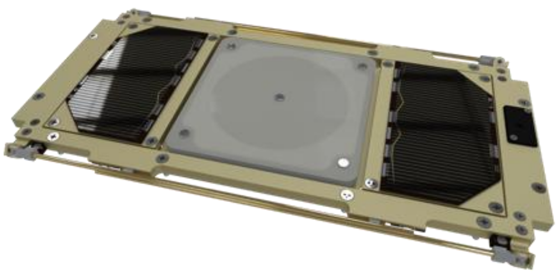
1 Overview

The GomSpace NanoCom ANT-6F UHF antenna for the UHF band (340 MHz - 680 MHz) is a deployable, omnidirectional and canted turnstile antenna system with rigid antenna elements, which eliminates the risk of antenna deformation while stowed.

Dual port design, provide redundancy by optionally connecting two RF transceivers e. g. two GomSpace NanoCom AX100 to the antenna boards at the same time to avoid loss of functionality in case of a single credible failure.

The separation of the antenna modules into two boards provide a smart way of supporting a wide range of supported frequencies and at the same time providing space for other systems on the top and bottom of the satellite.

The turnstile antenna system consists of four monopole antenna rods combined in a phasing network to form a single circular polarized antenna. The antenna radiation pattern is close to omnidirectional.
The ANT-6F is compatible with the GomSpace 6U structure and can be mounted on either the top or bottom of the structure. The antenna is designed such that in one end an UHF version can be mounted, and in the other end a VHF version can be mounted. See the ANT-6F VHF datasheet for more details.



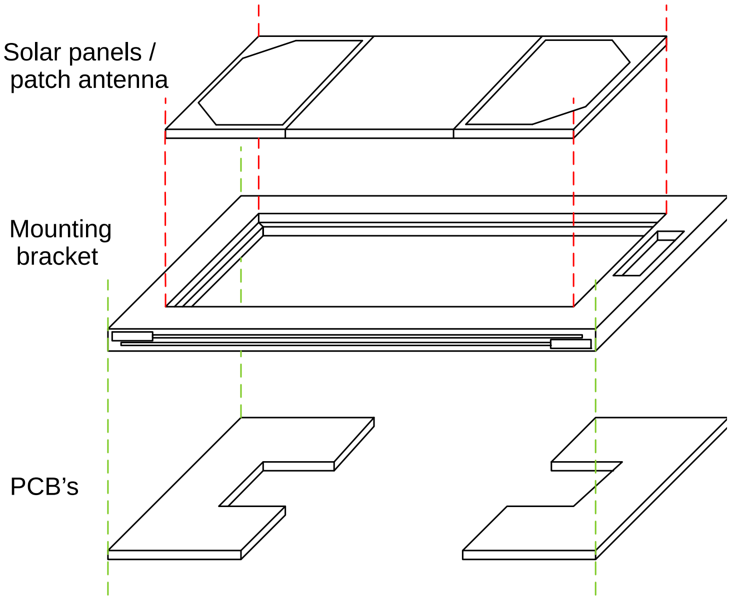


Figure 1-1: Ant 6F UHF Assembly shown with optional solar panels and patch antenna

ANT-6F UHF is made of three layers assembled with screws and helicoil inserts:

- The top layer is made of number of different modules depending on customer choices. Examples of choices can be solar panels, patch antennas, camera, propulsion etc. These are ordered through their own option sheet.
- The middle layer is an aluminium mounting bracket where the top and bottom layers are mounted on. This is also the location where the four UHF antennas rods are mounted and there is a slot reserved for the GomSpace Fine Sun Sensor (FSS).
- Bottom layer consists of two PCB's containing all the connectors, electronics and burn resistors for antenna release.

1.1 Highlighted Features

- Fits GomSpace 6U and 8U structures.
- Multiples of choices of top layer hardware.
- On a GomSpace 6U or 8U satellite an ANT-6F UHF can be mounted on one end, and an ANT-6F VHF at the other end.
- Dual port design to provide redundancy in case of a transceiver failure.
- Omnidirectional Canted Turnstile Antenna.
- Providing antenna release system mechanism.
- Providing mechanical switches for detection of the antenna release.
- Standard frequency ranges
  - ANT-6F-L 400 ± 10 MHz
  - ANT-6F-M 435 ± 10 MHz
  - ANT-6F-H 470 ± 10 MHz
- Frequency range custom design required: 340-680 MHz.
- Max. gain: 3 dB at 400 MHz.
- Absolute gain above -5 dBi with 95% probability at 400 MHz.
- Rigid antenna rods.
- Safe antenna rod stowage system.
- Matched to 50 Ω.
- PCB material: Glass-Polyimide.
- IPC-A-610 Class 3 assembly.

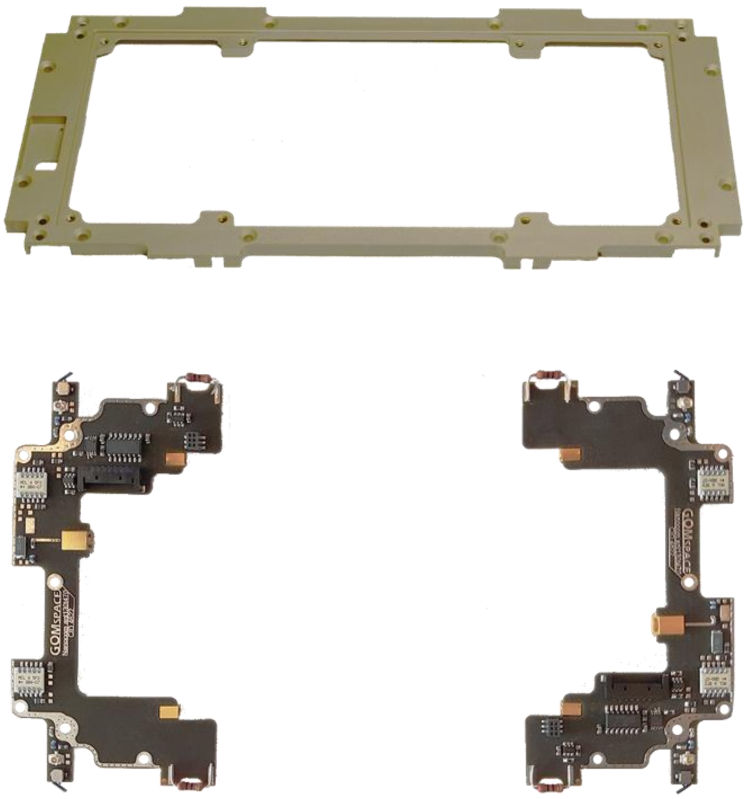


Figure 1-2: Ant-6F UHF Mounting bracket and PCBs.

1.2 Block Diagram

The block diagram below shows the communication and power pathways through the ANT-6F UHF system.

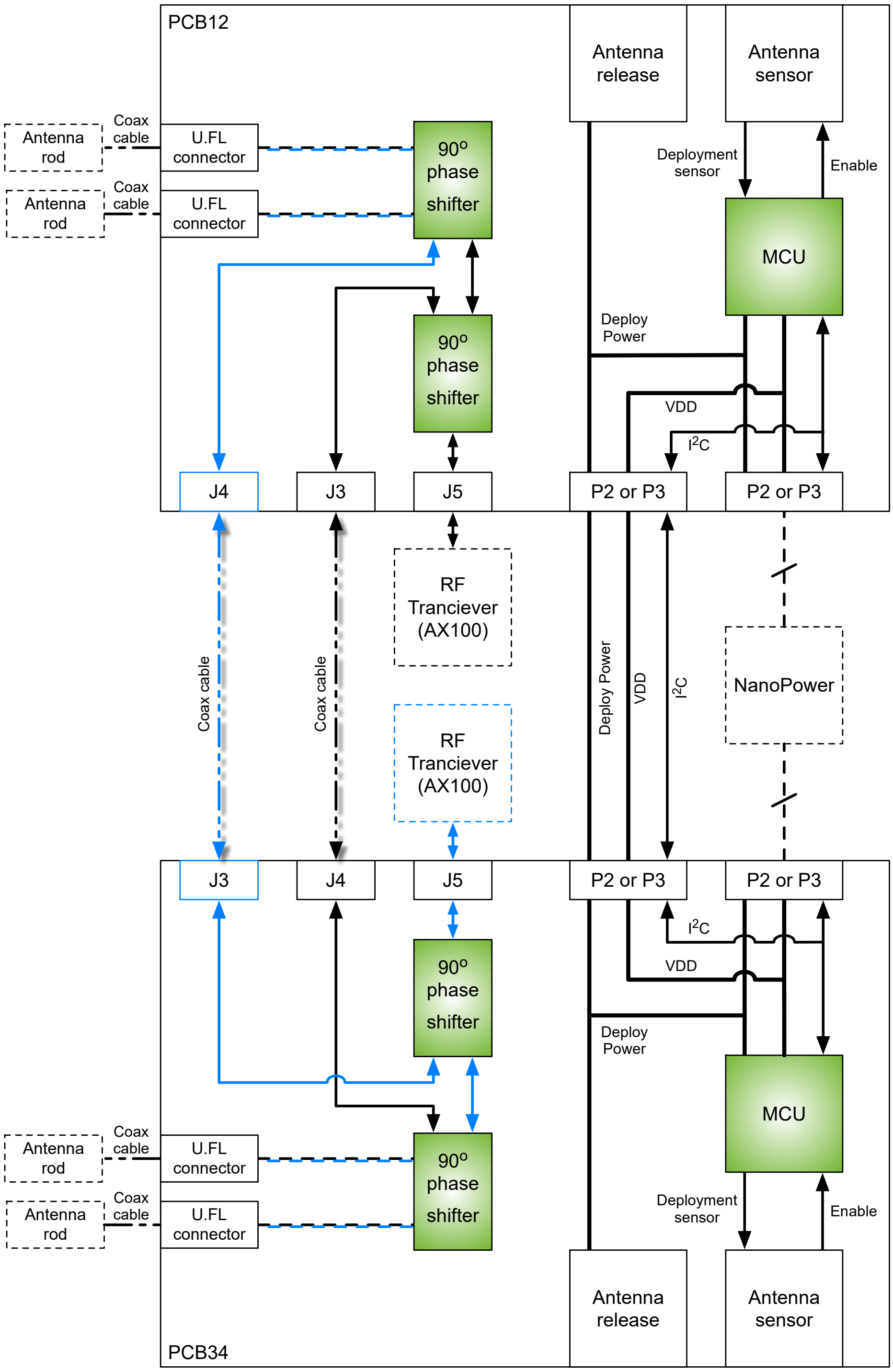


Figure 1-3: Ant-6F UHF Block Diagram.

Important: only connect one NanoPower to one connector. From here it supplies power to the entire system.

The blue pathways and connectors are only used in a certain set of mode, see the next chapter.

2 Mode of Operation

The four rods are arranged as a turnstile antenna and is fed in quadrature to give a polarized antenna pattern either Left Hand Circular Polarized (LHCP) or Right Hand Circular Polarized (RHCP). Polarization is defined by radiation in the Z+ direction (off the surface of mounting) – see **Figure 2-1**.

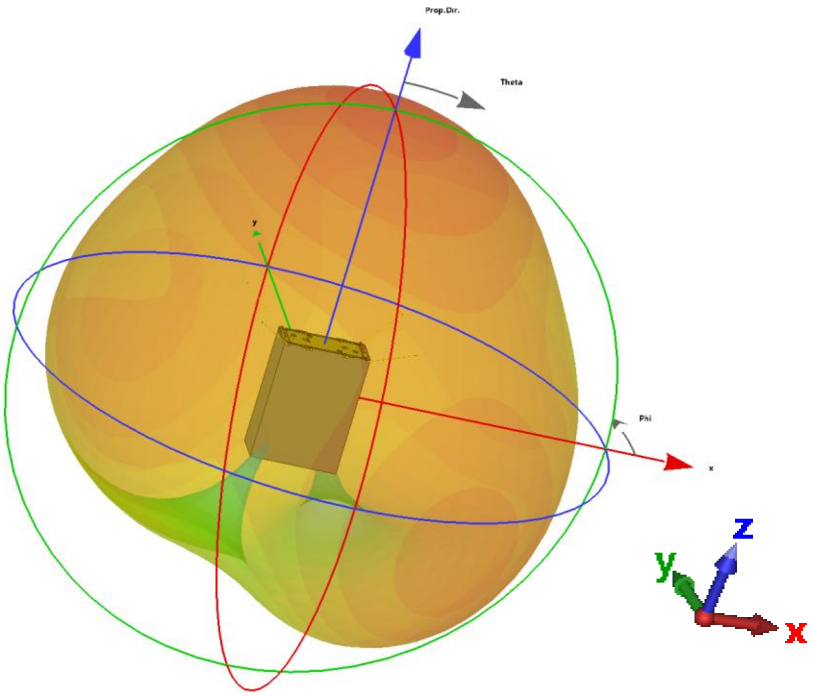


Figure 2-1: 400 MHz RCHP radiation pattern for mode 1 (RHCP mode).

The mode 1 will also radiate LHCP, but mainly in opposite direction – see Figure 2-2.

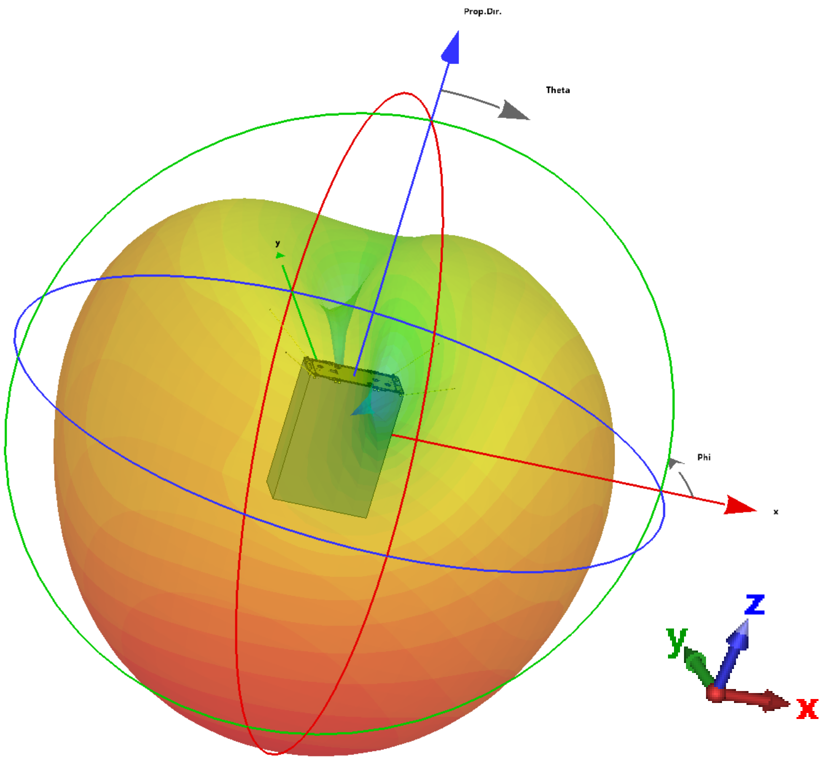


Figure 2-2: 400 MHz LHCP radiation pattern for mode 1 (RHCP mode).

Above, the mode 1 (RHCP) was shown. Selecting mode 2 (LHCP) will give same radiation except swapping RHCP and LHCP.

Below, the supported three modes of operation are described. Regardless of the choice of modes, two fixed coax cables with lengths based on selected frequency will be mounted as part of the feed arrangement.

For more information on antenna performance see chapter 10.

2.1 Mode 1

The RF module connects to input 1 and input 2 is terminated with 50 Ω resistors. Right-hand circular polarization (RHCP) applies. This mode follows the blue pathway on the block diagram.

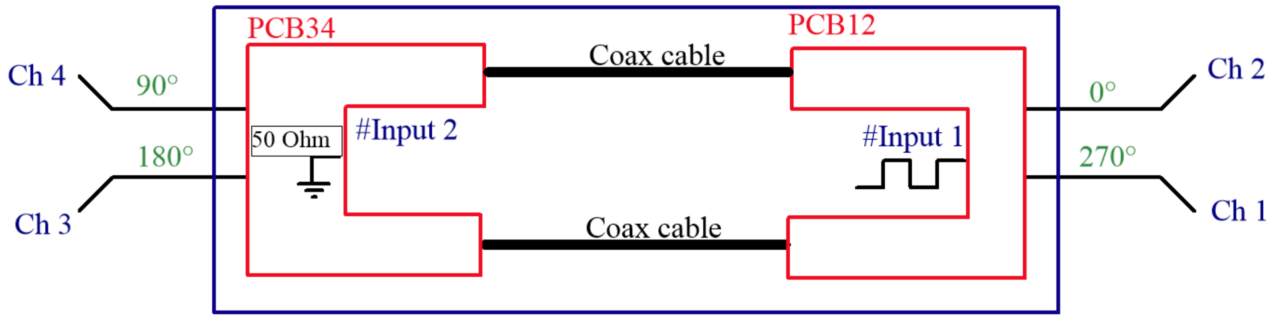


Figure 2-3: Seen from the top, 2U side. Input signal at Input 1 and detection at Ch2, Ch1, Ch3 and Ch4. Green numbers are the designed relative phase of the received signal in degrees at each channel (by taking channel 2 as a reference as an example). Each channel corresponds to an antenna rod.

2.2 Mode 2

The RF module connects to input 2 and input 1 is terminated with 50 Ω resistors. Left-hand circular polarization (LHCP) applies. This mode follows the black pathway on the block diagram.

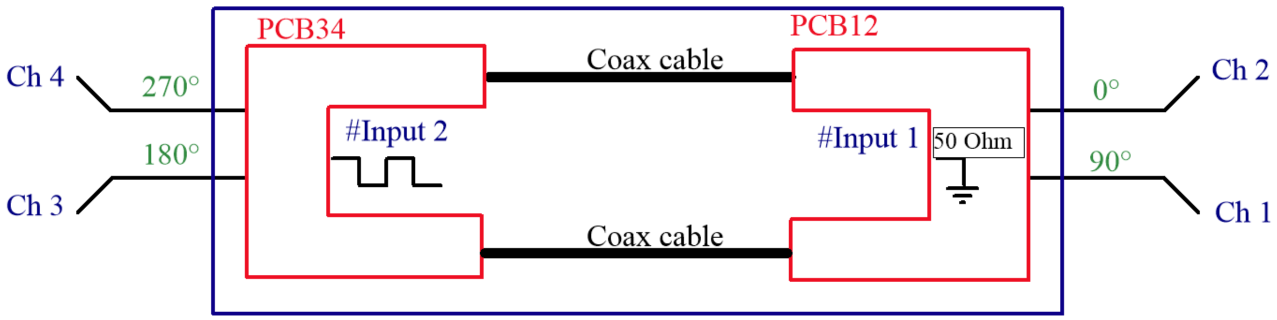


Figure 2-4: Seen from the top, 2U side. Input signal at Input 2 and detection at Ch2, Ch1, Ch3 and Ch4. Green numbers are the designed relative phase of the received signal in degrees at each channel (by taking channel 2 as a reference as an example). Each channel corresponds to an antenna rod.

2.3 Mode 3

The RF modules connect to input 1 and 2. Depending on the usage of input 1 or input 2, right-hand or left-hand circular polarization in Z+ direction applies. Only one of the inputs can be used at a time.
Terminate any unused port in this mode, input 1 or input 2.

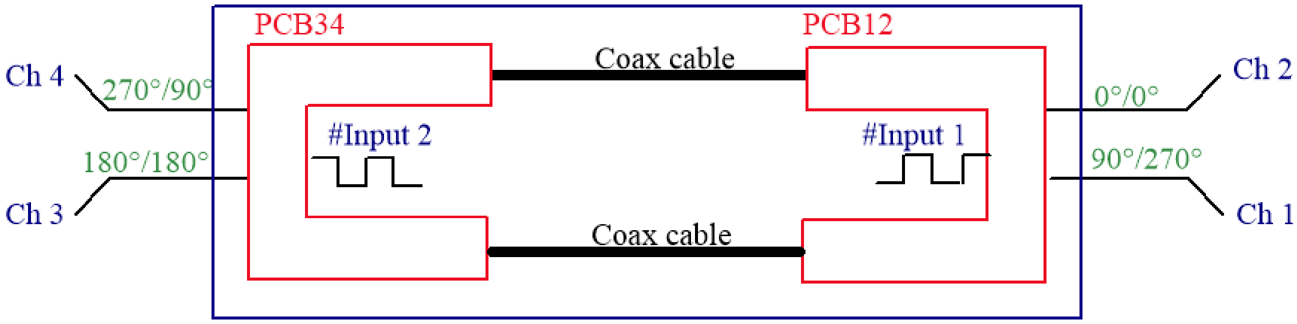


Figure 2-5: Seen from the top, 2U side. Input signal at Input 1 or Input 2 and detection at Ch2, Ch1, Ch3 and Ch4. Greens number are the expected relative phase of the received signal in degrees at each channel (by taking channel 2 as a reference as an example). Each channel corresponds to an antenna rod.

In case of a tumbling satellite, pointing direction of the satellite toward the ground station will results in changes between RHCP and LHCP radiation. As a result, the main difference of all the modes is a matter of supporting one or two transceivers for redundancy (please refer to Application in Chapter 17).

3 Antenna Deployment

The antenna release system is like what is used in previous GomSpace products (NanoUtil Interstage GSSB). This system has flown in several missions and deployed successfully every time.
All antenna rods are mounted on a hinge affixed to an impedance matching mounting bracket. The hinges are made of aluminium and PEEK to prevent antenna element grounding. The antenna line is routed through the hinge axis to prevent stress accumulation during the deployment. The antenna elements are during stowing held down by a Dyneema monofilament, which is connected to two independent burn resistors. The resistors are sequentially commanded to heat and melt the monofilament, releasing the UHF antenna. When the antenna is released, it will rotate to an angle of 45 degrees above the PCB. The spring is only tensioned to approximately half its safe rating in stowed mode, and it is thus safe to keep the antennas stowed indefinitely without effecting reliable deployment.

Parameter	Condition	Min.	Typ.	Max.	Unit
Spring Torque	Deployed	-	1.32	-	Nmm
	Stowed	-	5.31	-	Nmm

3.1 Active Antenna Deployment

A small mechanical switch on the edge of the release board detects the antenna deployment. Two of the antennas are tied together on one side of the mounting bracket and the other two tied together on the opposite side. When two of the resistors on one side melt, the monofilament on one side of the antennas release and provide deployment of two of the antennas. The same will occur for the two other antennas. The switches detect the deployment of the antennas in pair and send feedback to the power supply. Deployment of the antennas in pair provide more stability and prevent accidental deploy of each of the antennas in the pod due to the failure of one of the monofilaments. In case antenna is not deployed the gain will be significantly reduced. Based on simulation 13-20 dB gain reduction is expected.

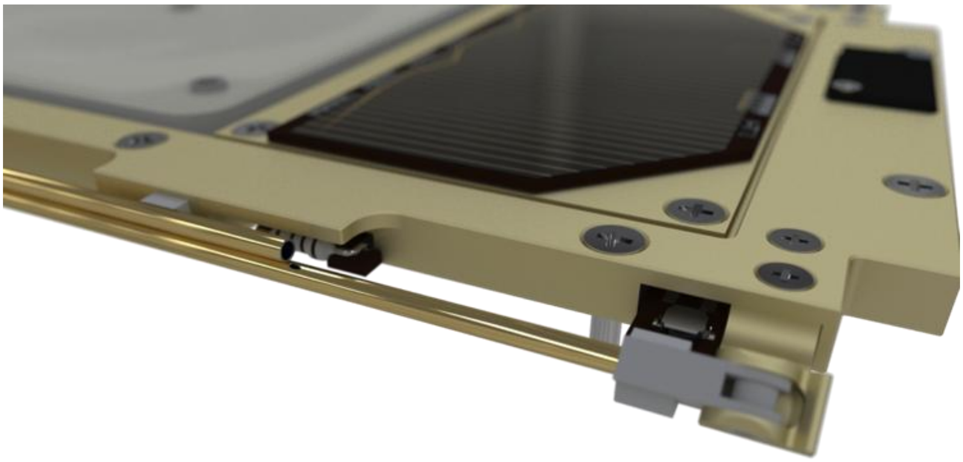


Figure 3-1: Detail of the antenna release mechanism showing the resistor and the hinge where the antenna is mounted and in stowed position.

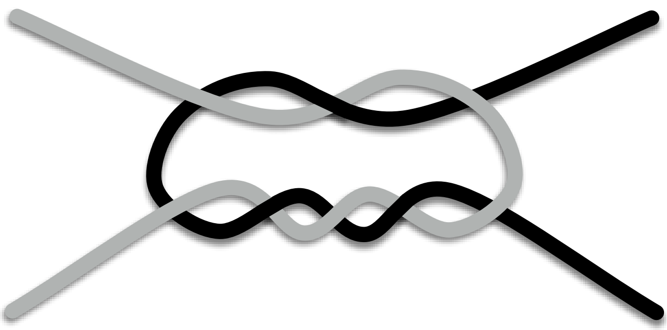
The monofilament can be easily replaced and, therefore, the antenna release can be tested before launch for every mission checking the proper behaviour.

3.2 Antenna Stowing Procedure

Procedure to tie up the antenna rods to the release mechanism:

1. Use 40 cm burn wire.
2. Place a loop of wire around the resistors, such that the wire is placed at the center of the resistor.
3. Tie the ends around both antenna rods using two surgeon's knots, one on top of the other.
4. Tie one end of the wire to the hole next to the resistors, to avoid the wire to float away after deployment (no space debri).
5. Use a knife or scissor to remove the remaining wire after the knot.

Surgeons Knot



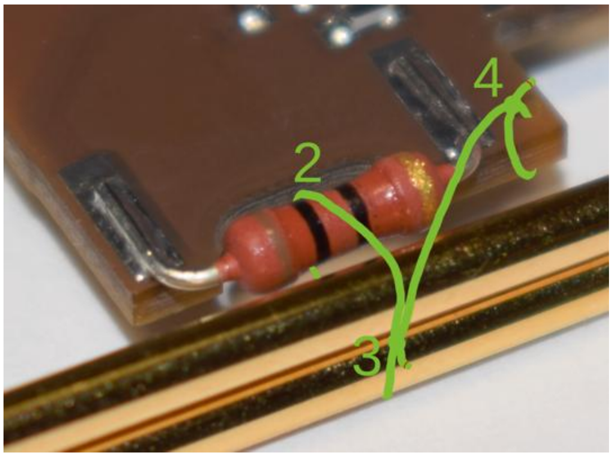


Figure 3-2: Antenna Rod Stowing.

4 Hardware Layout, Connectors and Pin Out

The two PCBs in each end are (in connector layout) the same. Below is only referred to one of them, the other half is identical.

4.1 ANT-6F UHF Top

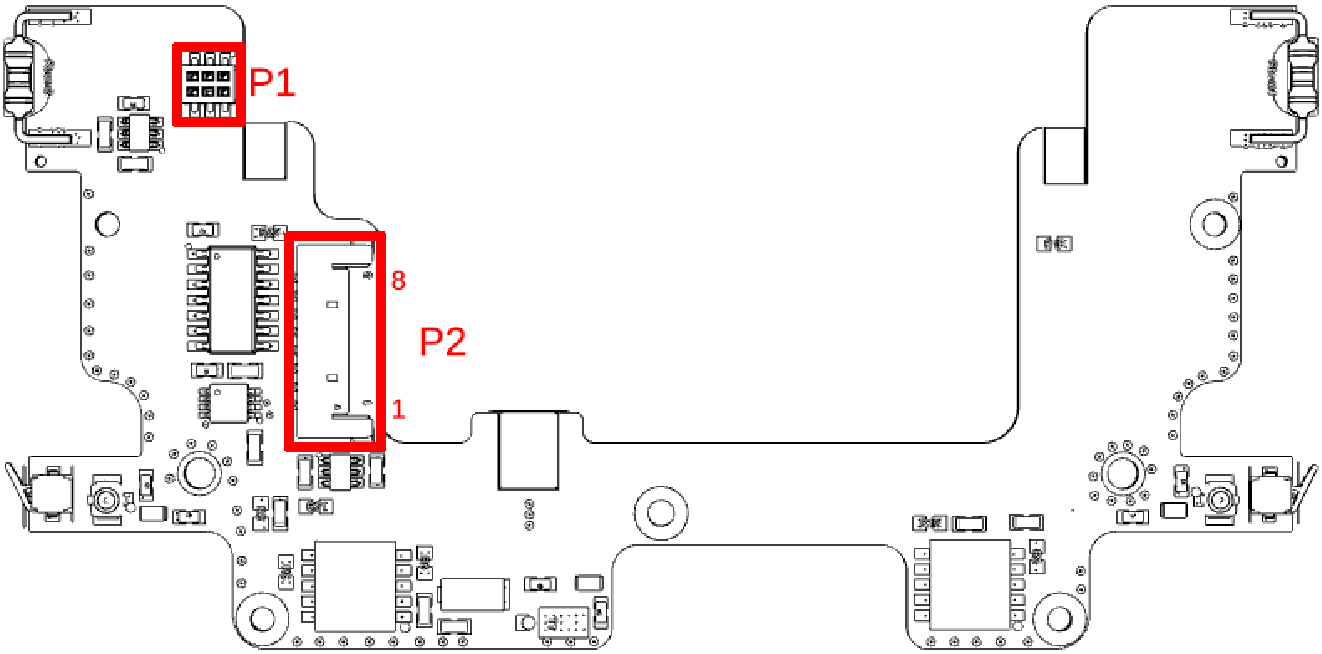


Figure 4-1: Ant-6F PCB Control Signal Connectors seen from top.

4.1.1 P1 – External Programmer

This connector is used for internal programming of the antenna boards. For updating the on-board program, please contact GomSpace.

4.1.2 P2 – GomSpace Release Bus (GSRB) Connector

Molex Pico-Lock 504050-0891.

This is used to connect to the GomSpace NanoPower P60 Dock (connector P6), to the other half of the ANT-6F or to NanoUtil AR6 (connector P2 or P3) in case of engaging ANT-6F VHF unit in the satellite.

Pin	Description
1	GND
2	GND
3	Burn_VDD
4	Burn_VDD
5	GND
6	GSSB_VCC
7	GSSB_SCL
8	GSSB_SDA

4.2 ANT-6F UHF Bottom

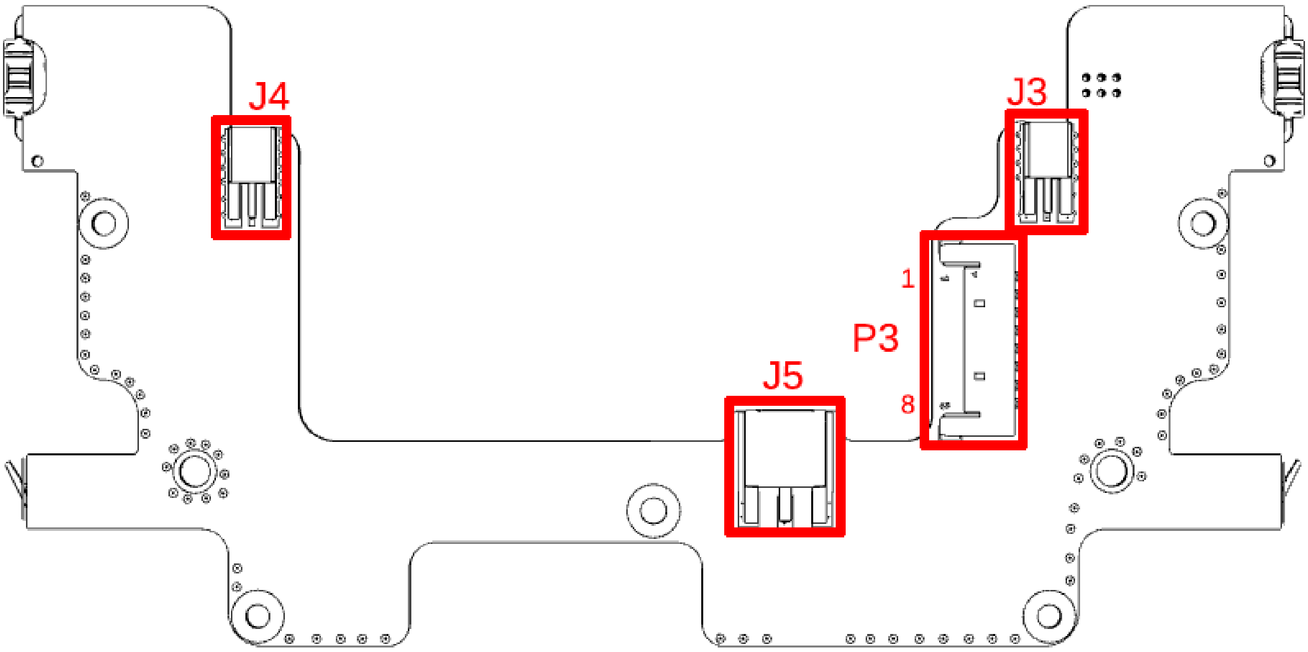


Figure 4-2: Ant-6F UHF coaxial and Control Connectors seen from bottom.

4.2.1 P3 – GomSpace Release Bus (GSRB) Connector

Molex Pico-Lock 504050-0891.

This is used to connect to the GomSpace NanoPower P60 Dock (connector P6), to the other half of the ANT-6F or to NanoUtil AR6 (connector P2 or P3) in case of engaging ANT-6F VHF unit in the satellite.

Pin	Description
1	GSSB_SDA
2	GSSB_SCL
3	GSSB_VCC
4	GND
5	Burn_VDD
6	Burn_VDD
7	GND
8	GND

4.2.2 J5 - MCX RF Connector

The RF connector is a 50 Ω MCX for edge mounting. Type Samtec MCX-J-P-H-ST-EM1. It works well with two right-angle connectors on RG316 cable to connect to a transceiver. Note the cables should be ordered with space-proof heat-shrink tubing to avoid outgassing in vacuum.

Figure 4-3 MCX connector and mating cable from Molex

4.2.3 J3/J4 - SMPM RF Connector

These RF connectors are SMPM and are used for the feed arrangement and are connected by GomSpace before shipping.

4.3 Connection to the Antenna Rods

The PCB's feed signals are connected to the antenna rods using a small connector located near the antenna deployment detector mechanism. The antenna rods are all connected to satellite chassis via a high impedance electrostatic charge bleed resistor to mitigate electrostatic charge on the rods.

5 Data Interface – Antenna Deployment

The NanoCom ANT-6F UHF uses I^{2}C communication. It is driven in I^{2}C slave mode, and the default address is 0x05 and 0x06. It must be connected to the GSSB (GomSpace Sensor Bus). An API with the different functions used for deployment is found in the GSSB library provided by GomSpace.

6 Absolute Maximum Ratings

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the ANT-6F UHF. Exposure to absolute maximum rating conditions for extended periods may affect the reliability.

Symbol	Description	Min.	Max.	Unit
T	Temperature	-40	90	°C
VCC	Supply voltage		3.4	V
BURN B1	Burn resistor voltage		7	V
I_BURN	Current over burn resistor		1	A
t_BURN[1]	Total burn time of each burn resister		20	s
n_BURN1[1]	number of activation times of each burn resistor		5	

7 Electrical Characteristics

Symbol	Description	Min.	Typ.	Max.	Unit
VCC	Supply voltage		3.3		V
I	Supply current		50		mA
BURN B1	Burn resistor voltage	4.5	5	7	V
I_BURN	Current over burn resistor	0.4	0.5	1	A

8 RF Performance Characteristics

Parameter	Condition	Min.	Typ.	Max.	Unit
RF impedance	Deployed	-	50	-	Ω
Input RF power		-	2	5*	W
VSWR at matching point	Individual antenna		1.15	2	
VSWR at feed point			1.1	2	
Antenna system insertion loss	at 400 MHz	1	2	2.2	dB
Isolation between the two input ports			15		dB
Frequency range for ANT-6F-L		395		405	MHz
Frequency range for ANT-6F-M		430		440	MHz
Frequency range for ANT-6F-H		465		475	MHz
Temperature range		-40		85	°C

*For higher output power contact GomSpace

9 Physical Characteristics

Description	Value	Unit
Total mass of ANT-6F UHF, including antenna rods	90	g
Size of full system, not including antenna rods	221.7 x 116.7 x 5.3	mm
Length of antenna rod from hinge to tip	163	mm

[1] Laboratory values for testing purposes

10 Antenna Performance

10.1 Antenna Radiation

The antenna is designed with the goal of avoiding dead spots in the radiation pattern by having close to omnidirectional absolute gain defined as minimum gain in as large a portion of the enclosing sphere as possible. The antenna is designed for circular polarization to mitigate polarity propagation rotation and polarity alignment dependency on ground station. Depending on which antenna PCB connects to the transceiver, seen from top, can be left hand (LHCP) or right hand (RHCP) circular polarization. The same applies for the bottom side – See chapter 2.

10.2 Radiation Pattern

Radiation Pattern for a 6U Satellite has been simulated (CST) and measured using a Satimo ring antenna measurement system.
The orientation of the satellite placed in the Satimo System is illustrated in Cartesian and Spherical coordinate system – see Figure 10-1.

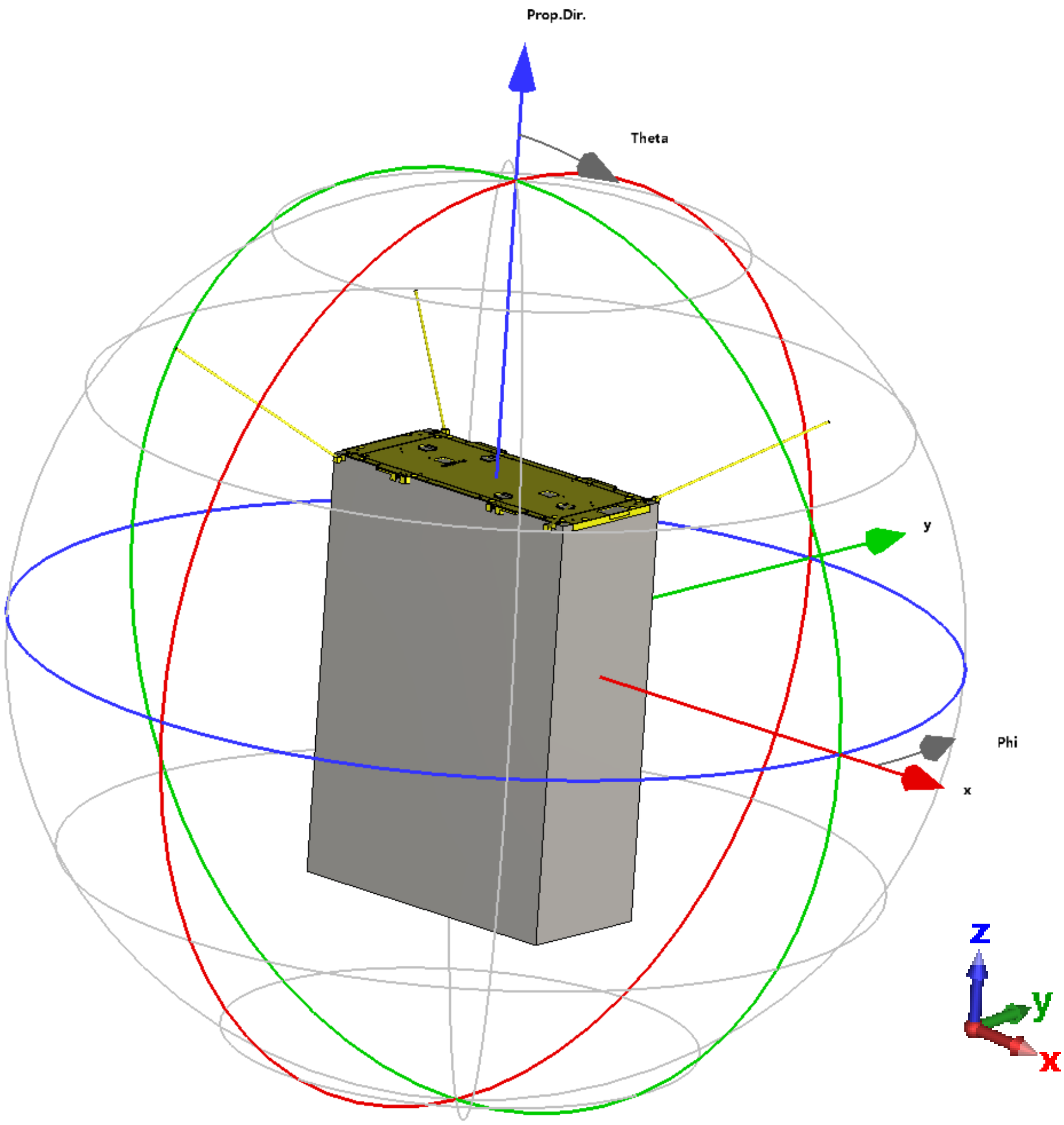


Figure 10-1: Satellite coordinate system illustration in Cartesian and Spherical coordinates.

The actual gain characteristics depend on the shape of the spacecraft and its deployable structures. For the GomSpace GOMX4 satellite, which does not have any deployable system except for Ant-6F antenna rods, the results for the measured realized gain by a Satimo System is shown both in linear and polar coordinates in Figure 10-2 to Figure 10-5.
The measured realized gain results illustrated below include all losses from MCX connector to far-field.

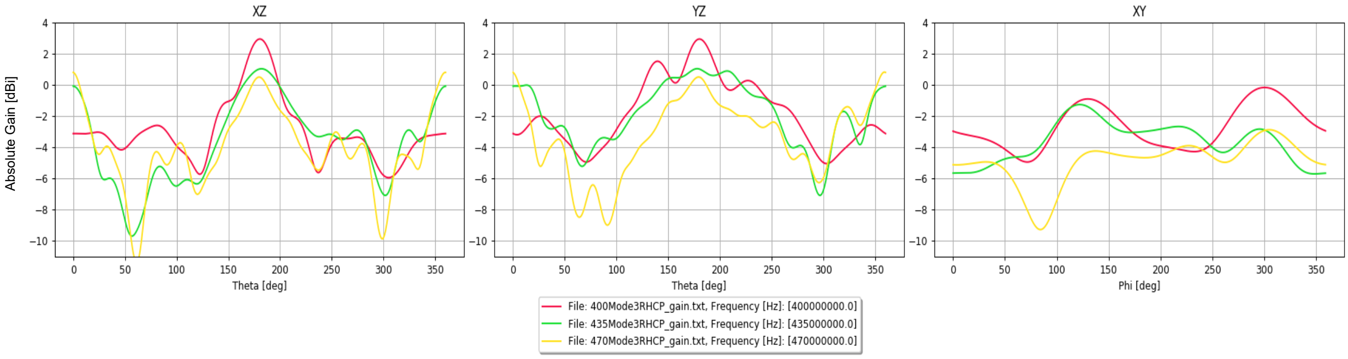


Figure 10-2: Absolute realized gain measured in the Satimo System for 400MHz, 435MHz and 470MHz variants in mode 1 (RHCP). The illustration shown linearly in three different orientations.

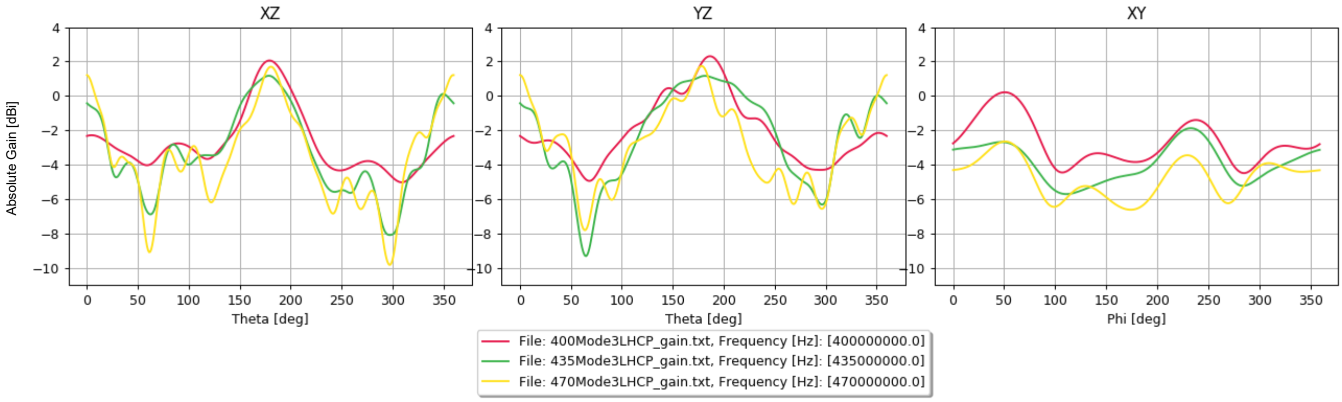


Figure 10-3: Absolute realized gain measured in the Satimo System for 400MHz 435MHz and 470MHz variants in mode 2 (LHCP). The illustration shown linearly in three different orientations.

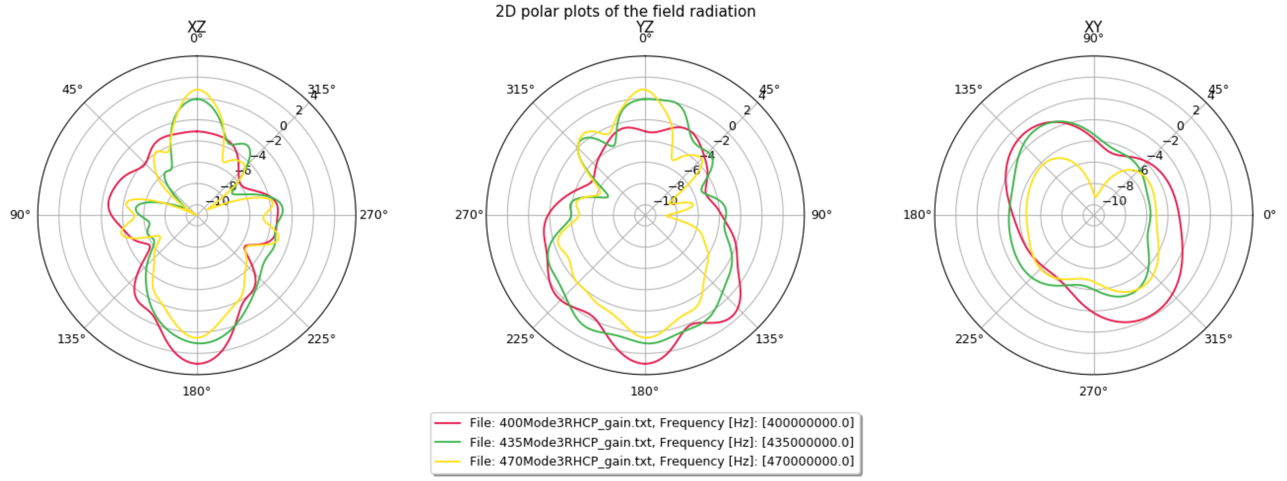


Figure 10-4: Absolute realized gain measured in dBi in the Satimo System for 400MHz 435MHz and 470MHz variants in mode 1 (RHCP). The illustration shown in Polar coordinate in three different orientations.

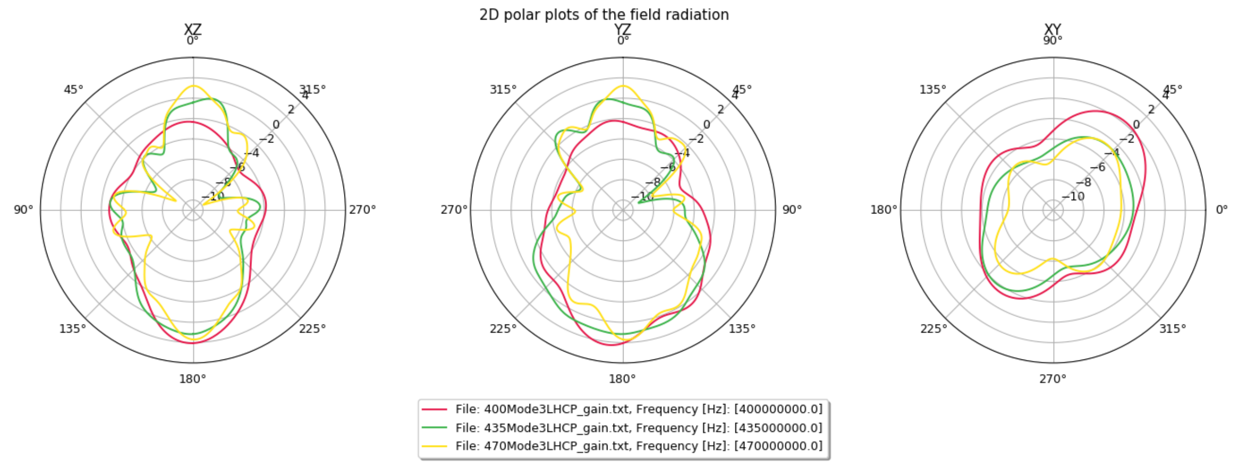


Figure 10-5: Absolute realized gain measured in dBi in the Satimo System for 400 MHz, 435 MHz and 470 MHz variants in mode 2 (LHCP). The illustration shown in Polar coordinate in three different orientations.

Due to the high correlation between Simulation and measurements, above 80% correlation in amplitude, below is the represented radiation pattern from Simulation. Gain representation is the absolute realized gain in dBi in 3D view, independent of the polarisation (RHCP or LHCP) for all the three variants. Realized gain includes feed network loss (thermal and reflection loss).

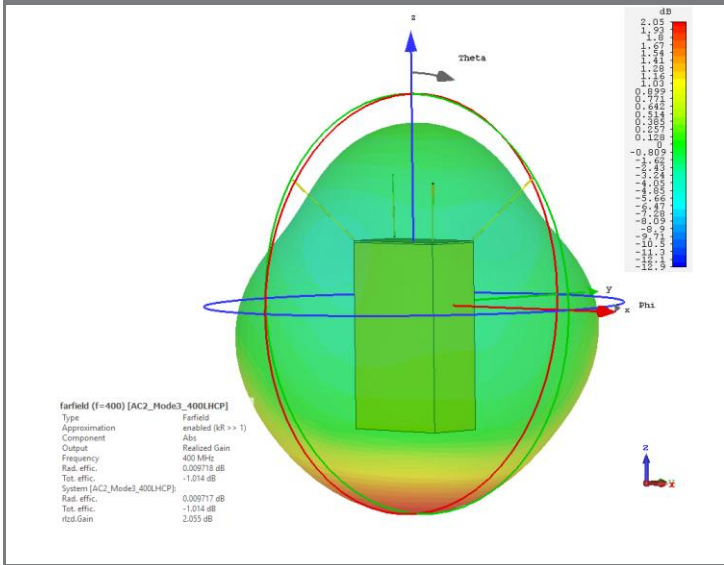
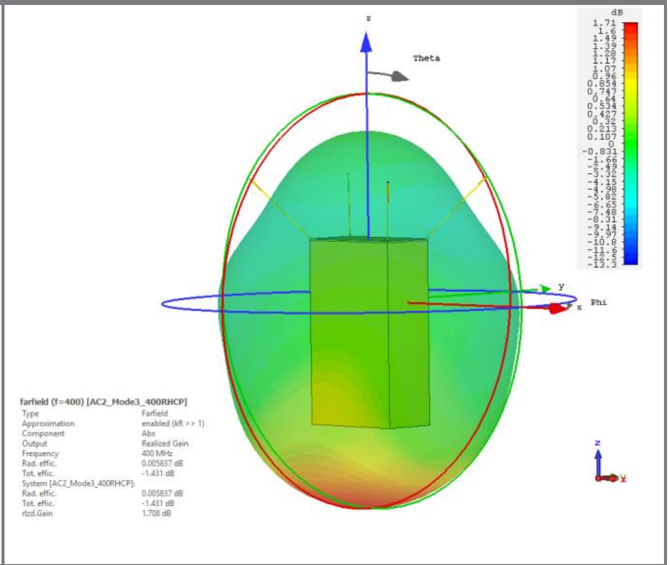
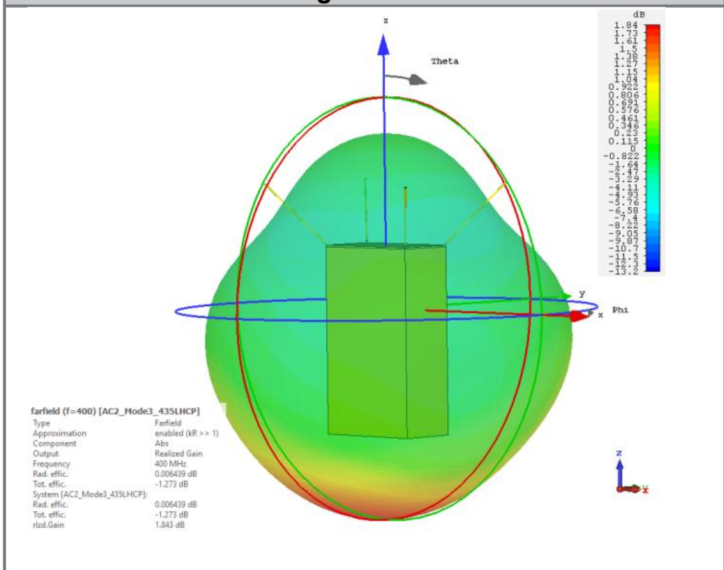
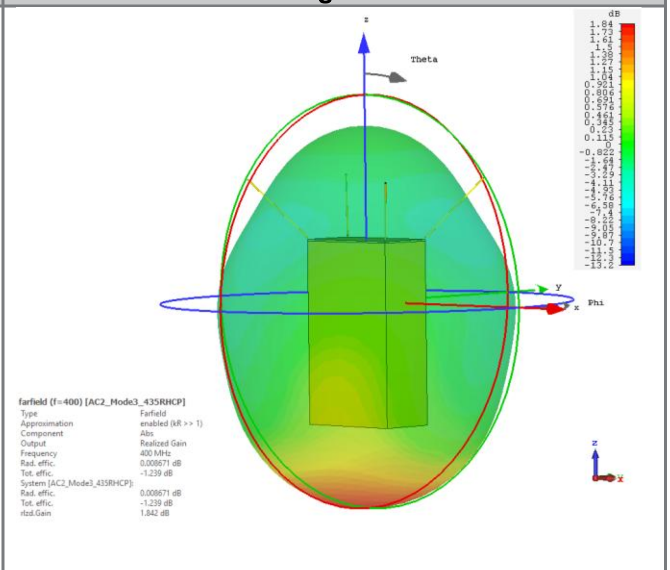
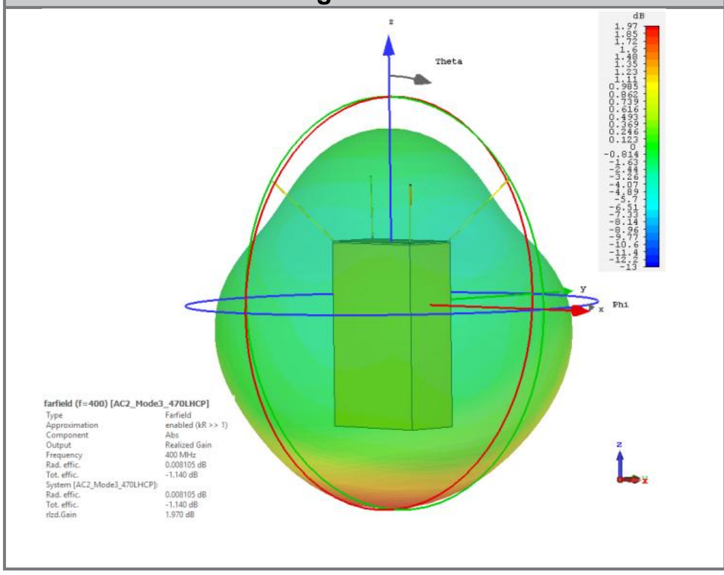
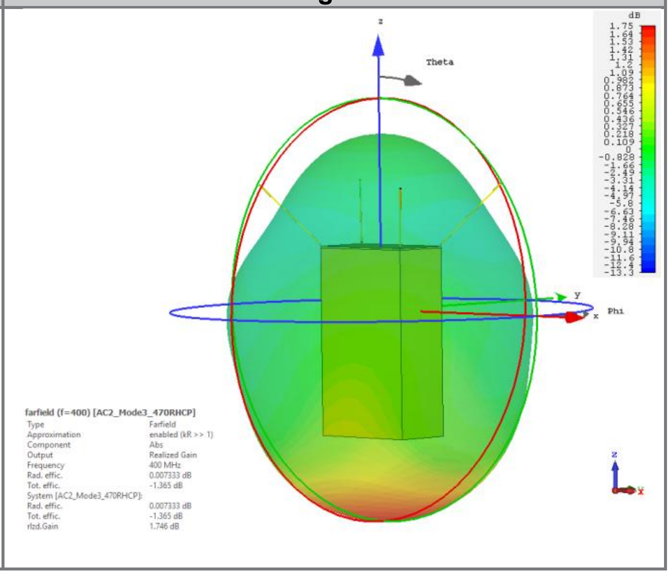
400MHz for LHCP Configuration	400MHz for RHCP Configuration
	
435MHz for LHCP Configuration	**435MHz for RHCP Configuration**
	
470MHz for LHCP Configuration	**470MHz for RHCP Configuration**
	

Figure 10-6: Absolute realized gain in 3D view simulated using CST software.

As can be seen in the above figures, the highest gain (2.05 dB for 400MHz in RHCP variant) is in the Z-direction of the CubeSat, opposite direction of the antenna location.

If you are in doubt that the shape of your satellite or deployable will affect the gain of the antenna, GomSpace can provide simulated gain plots for your specific satellite upon request. Contact GomSpace sales for further information.

10.3 Absolute Gain Probability

The probability that the absolute gain will be above a certain gain level has been illustrated using complementary cumulative distribution function. As an example, for the 95% probability the absolute gain for RHCP configuration will be above -7dBi for 470 MHz, -6dBi for 435 MHz, and -5dBi for 400 MHz. Also, for the 95% probability the absolute gain for LHCP configuration will be above -6dBi for 435 MHz, -6dBi for 470 MHz, and -4.5dBi for 400 MHz.

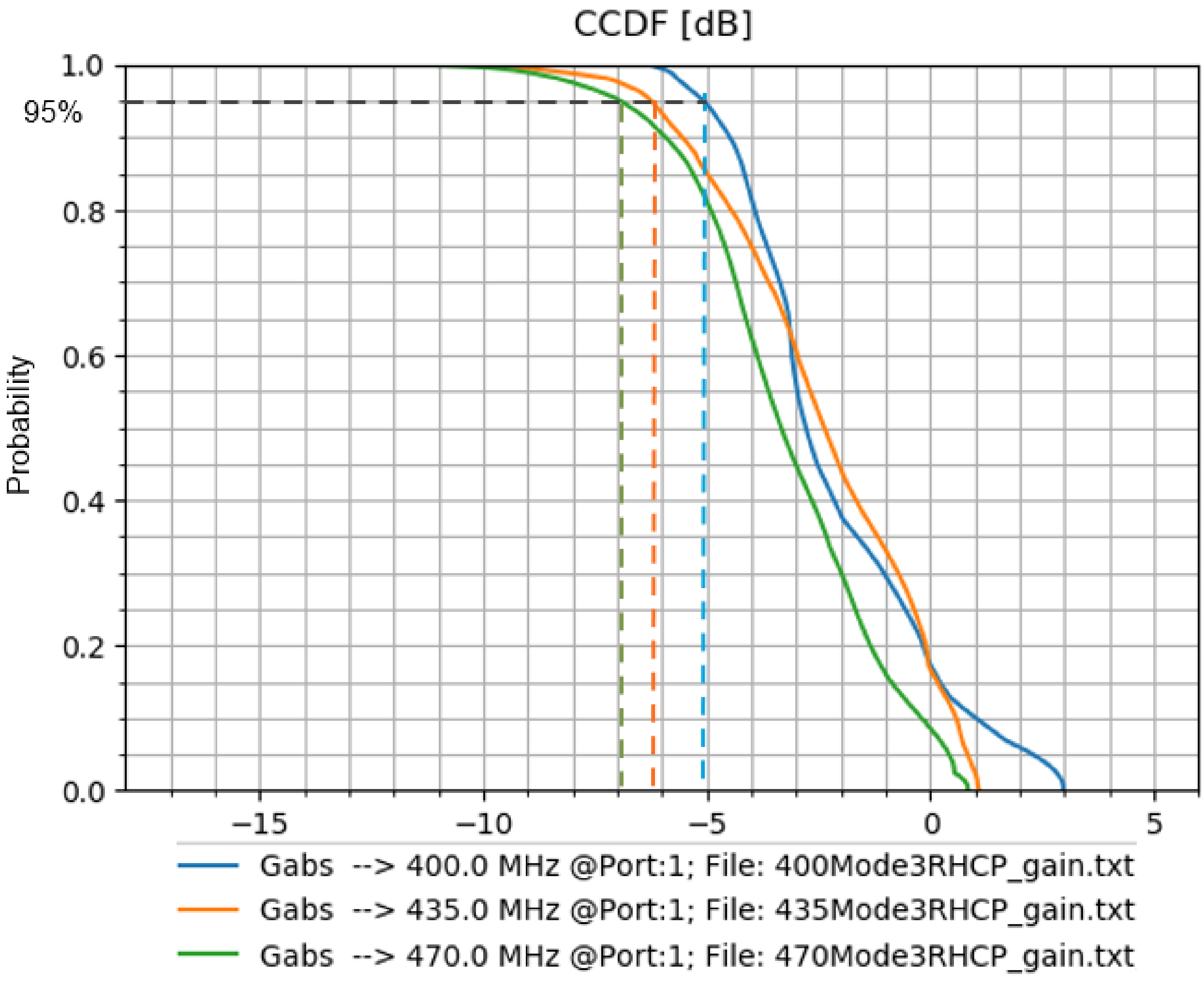


Figure 10-7. Absolute Gain Probability in dBi for RHCP configuration

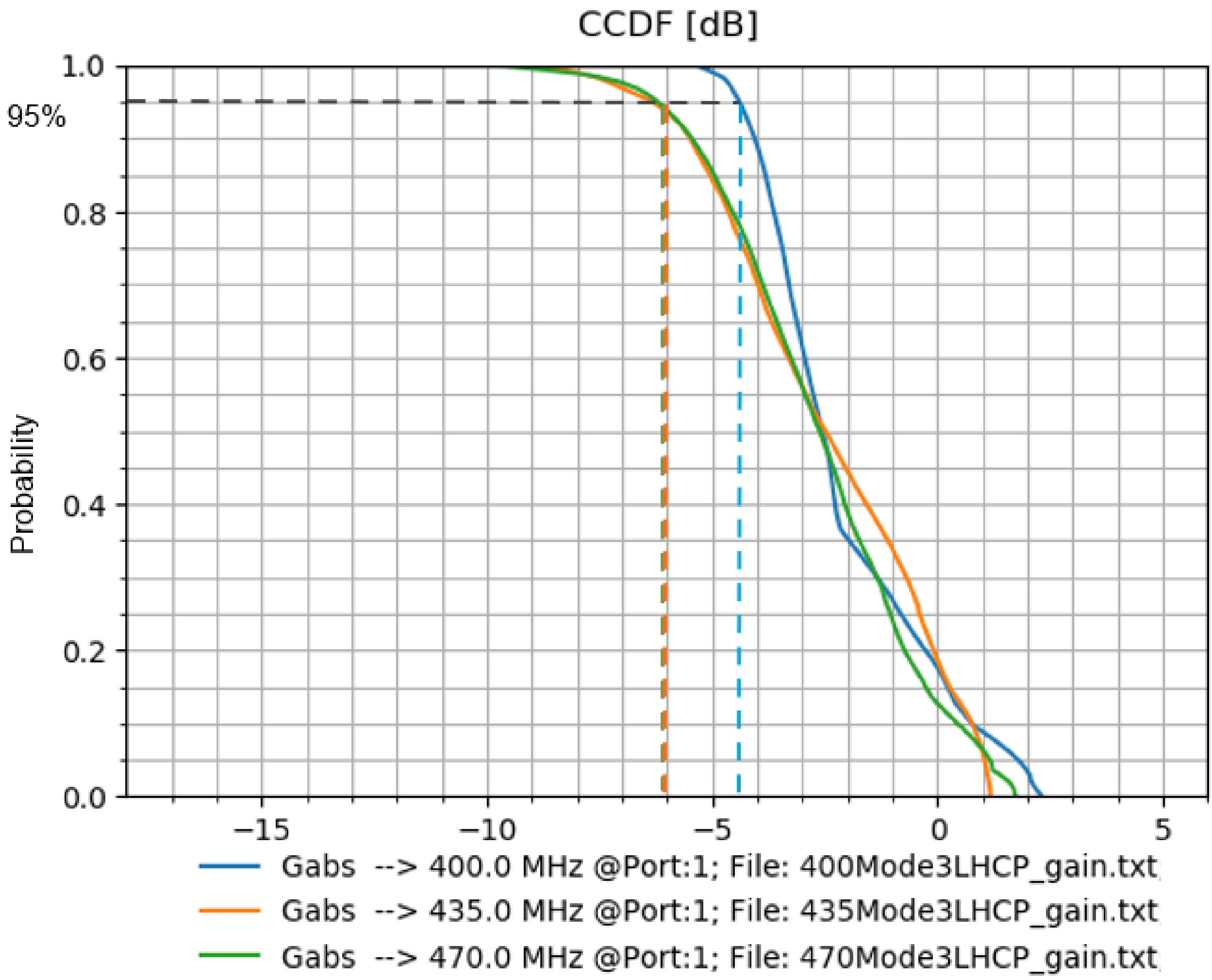


Figure 10-8. Absolute Gain Probability in dBi for LHCP configuration

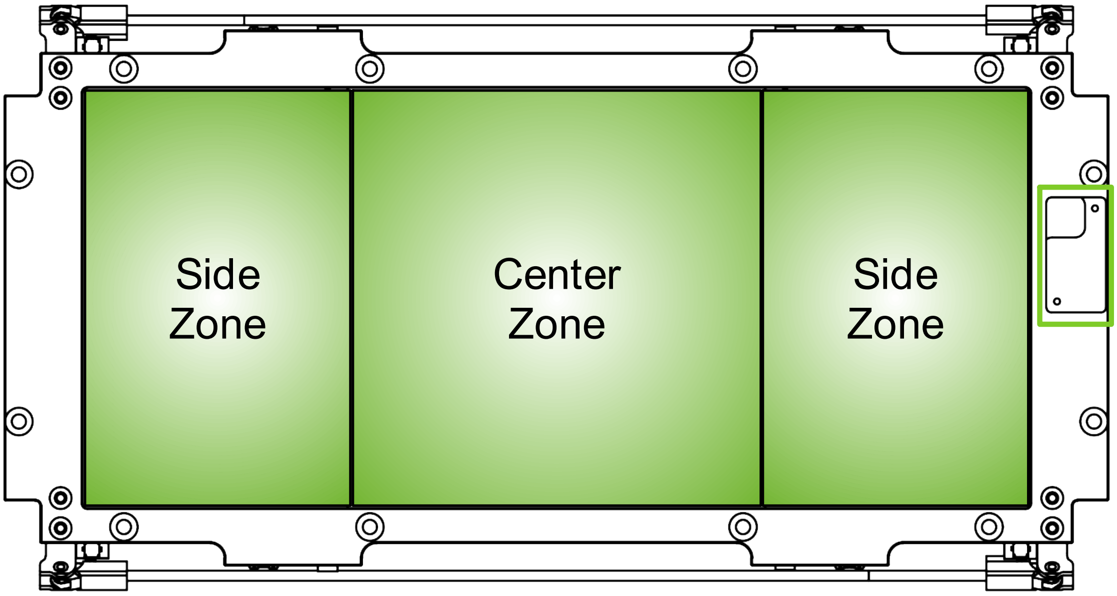
10.4 Dual Port Usage Caution – Input port Isolation

The isolation between the two RF ports on the Ant-6F- UHF is 15 dB and there is no protection circuit on the antenna board.
In the case of using AX100 as a transceiver, transmitting 30 dBm on one port for example will result in about 15 dBm on the other port. If the non-transmitting AX100 is off, meaning the 3.3V power is off, there will be no damage to the RX or TX chain on AX100. The main problem will appear when one module is in transmitting mode and the other one is in receiving mode, since feeding 15 dBm into the receiver chain could damage the receiver on AX100 (not the transmitter chain). Therefore, to avoid this situation, it has been specified in the datasheet to not use both ports on Ant-6F at the same time.

In the case of reception, there will be no issue to receive a low signal (in the order of -100 dBm) in space at the same time. But since AX100 configured to transmit back after receiving a correct package, there will be a risk of damage on the second AX100. Therefore, it is highly recommended to use one of the transceivers only and turn off the other one even in receiving mode.
Main reason to attach two AX100 is redundancy in the case of failure of one of the transceivers and NanoCom Ant-6F has not been designed to accommodate full communication with two transceivers with full protection.

11 Top Layer Modularity

The top layer is divided into three areas, a center zone, and two side zones. In each of the areas different modules can be mounted.



GomSpace has s number of products that fits in the zones. View the table below.

	Modular Antenna System Mounting Options
Center Zone	NanoCom ANT2000 Antenna NanoSpace Propulsion Adapter NanoPower Modular 4-Cell Panel *
Side Zones	NanoUtil MSP-FPP module** NanoCam C1U *** NanoPower Modular 1-cell panel NanoPower Modular 4-cell Panel *

* 4-Cell Panel uses the center zone and the two side zones.

** The MSP-FPP extends 7 mm above the GomSpace 6U structure corner rails (not including kill switches) make sure it fits in your launch pod.

*** The C1U camera sits as an extension of the PC104 stack and takes up a side zone and half the center zone. Special covering plate is ordered through contact with a GomSpace Sales.

At the far right there is room for a GomSpace NanoSense Fine Sun Sensor.

The listed product in the table above and the sun sensor is ordered through their own product option sheet.

The ANT-6F comes with aluminium plates covering the three zones. Customer mounts their ordered zone options themselves.

12 Frequency Variants

The ANT-6F UHF comes in several variants. The difference is in the individual rod match and the coax cable used.

Variant	Description
NanoCom ANT-6F-L	UHF 400 MHz
NanoCom ANT-6F-M	UHF 435 MHz
NanoCom ANT-6F-H	UHF 470 MHz

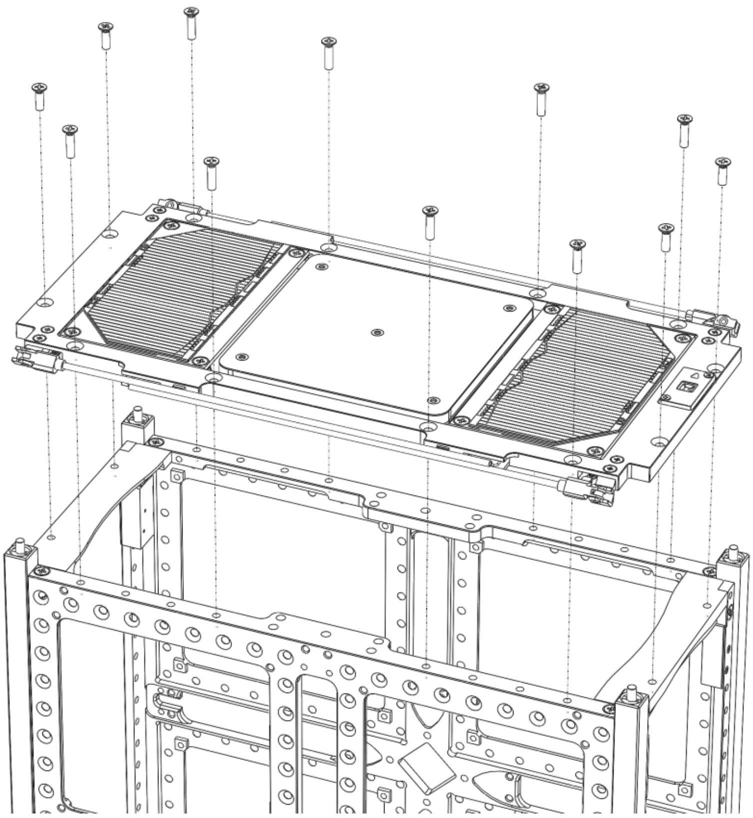
13 Environmental test

To simulate the harsh conditions of launch and space, the ANT-6F has been exposed to several environment tests. Contact GomSpace for further information.

14 Integration

The mounting bracket is mounted flush to the PCB ground plane on the upper side and is fixed with M2 screws via countersunk screw holes on the PCBs.

To assemble the frame on the 6U structure, use M2.5 X 8 on the short sides and M2.5 X10 screws on the long sides.



15 Application Notes

Having the same transceiver used together with ANT-6F UHF or-and ANT-6F VHF in both ends of a link greatly simplifies both the hardware and software development.

15.1 Antenna-Receiver Diversity Setup

The polarization of the radio-link will vary depending on the satellite antennas and the satellite orientation. This antenna type is ideal for satellites that may be tumbling around its own axis because it can be received on a linear element with a maximum alignment loss of 3 dB provided all four antennas are used. The optimal solution would be to continuously monitor and switch between polarizations of the ground station antenna.

15.2 Redundant Radios

Having two identical radios on the satellite removes a single point of failure.

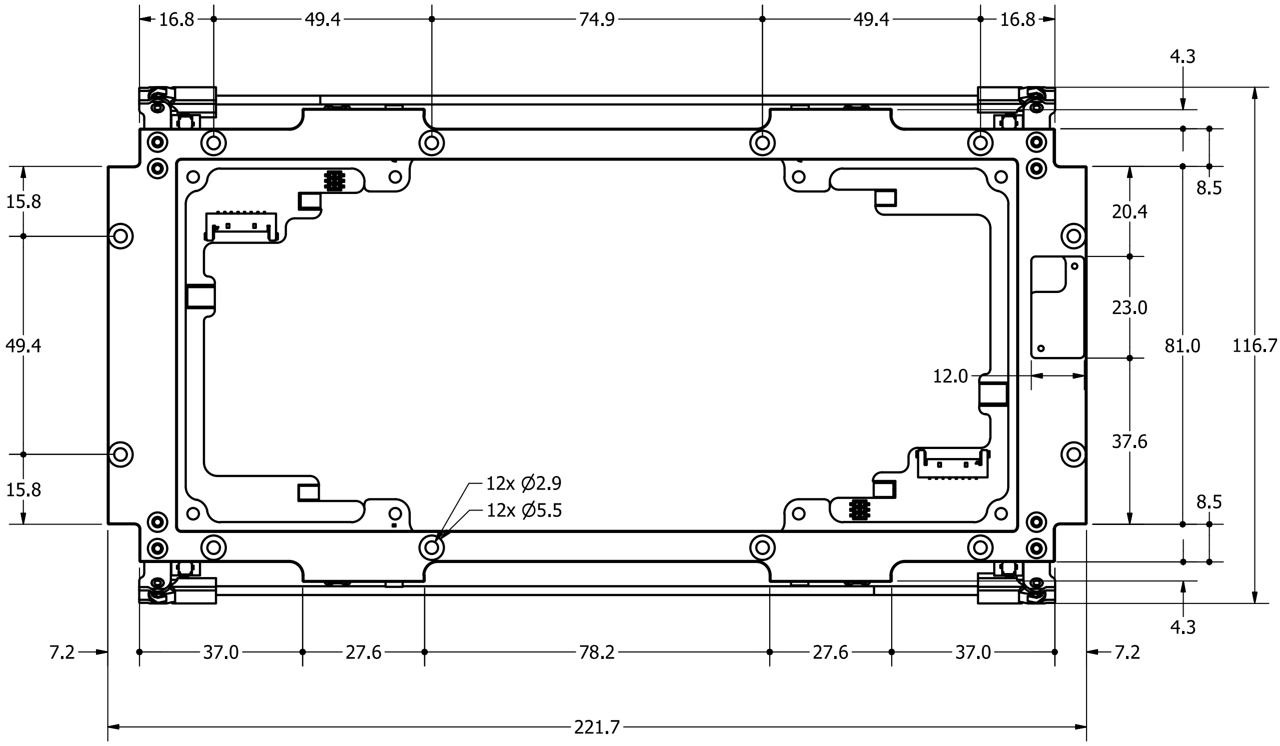
By connecting two AX100 for example to ANT-6F UHF, cold redundant AX100 radios would be controlled by the OBC or another system by simply switching the power to the AX100’s off and on. In cold redundant mode, only one out of the two radios can be switched on at a time, and they share the same network address and settings. (See the AX100 datasheet for further information.)

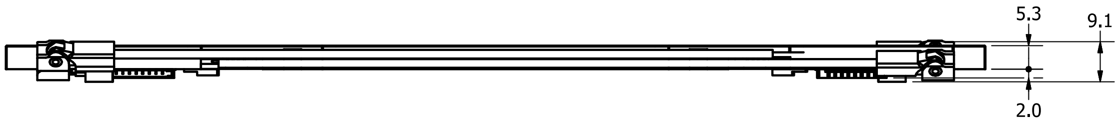
Another possibility would be to combine two AX100’s as VHF-UHF. As an example, have an ANT-6F UHF in end of a satellite and an ANT-6F VHF in the other end of the satellite. Each connected to their own AX100. This would enable operation of both radios simultaneously for either two half-duplex links or a single full-duplex link. Note: GomSpace have not yet tested full duplex in operation.

15.3 GomSpace Ground Support

The GomSpace NanoGround product includes support for UHF communication based on AX100 transceiver with the NanoGround AX Connect extension.

Mechanical Drawing
All dimensions in mm.





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