

NanoCom Ant-6f UHF

Datasheet

UHF antenna for GomSpace 6U structure

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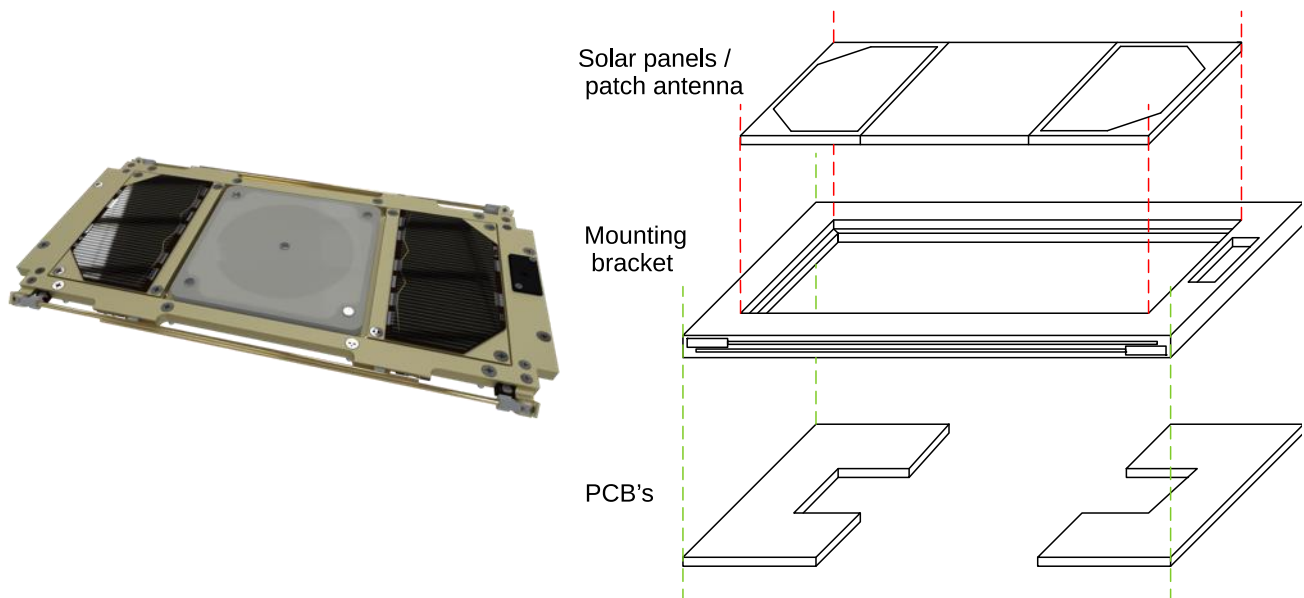
2 Overview

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 of antenna boards, provide possibility of connecting two RF transceivers to the antenna boards at the same time and being used one at the time as redundancy. The separation of the antenna modules into two boards provide a smart way of supporting a wide range of frequency and at the same time providing more 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.

With a dual port design, it provides redundancy in RF communication. are two possible connections to two RF transceiver (for example two GomSpace NanoCom AX100) inside the satellite from either of the feeding points on the PCBs. This is to avoid loss of functionality in case of any credible single failure.

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 can be mounted, and in the other end a VHF version can be mounted. See the ANT-6F VHF datasheet for more details.



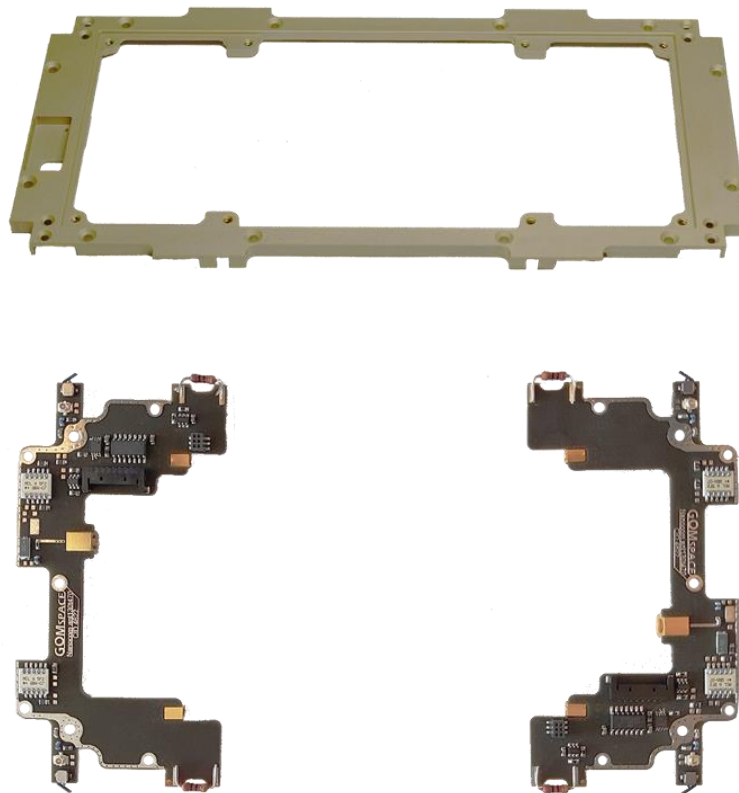
ANT-6F UHF is made of three layers assembled with screws and helicoils:

- 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 aluminum mounting bracket where the top and bottom layers are mounted on. This is also the location where the four UHF antennas rods are mounted as well as a slot is reserved for a GomSpace Fine Sun Sensor (FSS).
- Bottom layer consists of two PCB's containing all the connectors, electronics and burn resistors for antenna release.

Note: ALL PICTURES SHOWN IN THE DATASHEET ARE FOR ILLUSTRATION PURPOSE ONLY. ACTUAL PRODUCT MAY VARY DUE TO PRODUCT ENHANCEMENT.

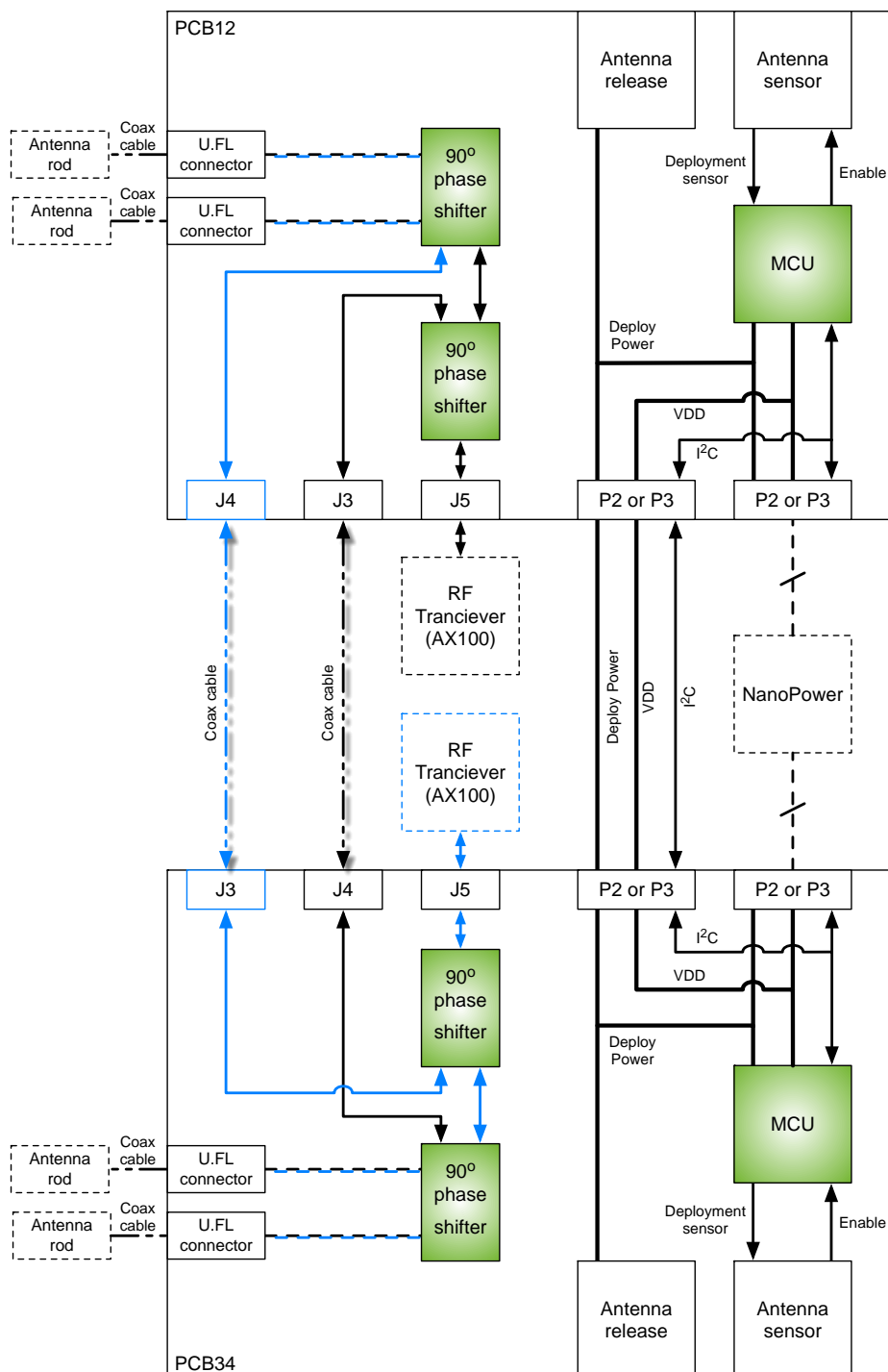
2.1 Highlighted Features

- Fits GomSpace 6U structure
- Multiples of choices of top layer hardware
- Consists of two rigid PCBs connecting with a coax cable with fixed length depending on the requested frequency
- In a GomSpace 6U 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
- Frequency range: 340-680 MHz
- Max. gain: 3 dB at 400 MHz
- Absolute gain above -7dBi with 95% probability
- Rigid antenna tubes
- Safe antenna rod stowage system
- Matched to 50 Ω
- PCB material: Glass-Polyimide
- IPC-A-610 Class 3 assembly



2.2 Block Diagram

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



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.

3 Mode of Operation

Polarization is in this document defined as viewed from the top of ANT-6F. Below are illustrated three modes of operation, depending on where the RF transceivers connect. Regardless of the choice of modes, two coax cables will be mounted since it affects both phase and relative gain measurements.

3.1 Mode 1

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

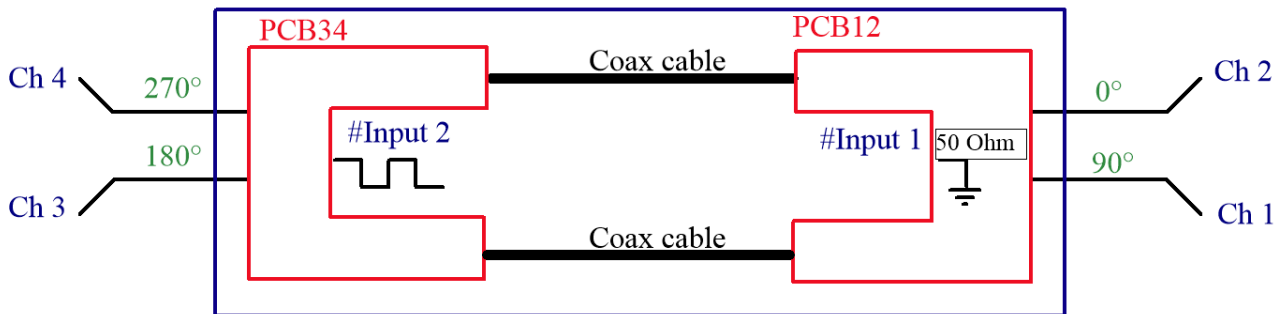


Figure 1 6U structure from the top, 2U side. Input signal at Input 1 and detection at Ch2, Ch1, Ch3 and Ch4. Green numbers are the expected relative phase of the received signal in degrees at each channel (by taking channel 2 as a reference as an example). Each channel corresponds to an antenna rod.

3.2 Mode 2

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

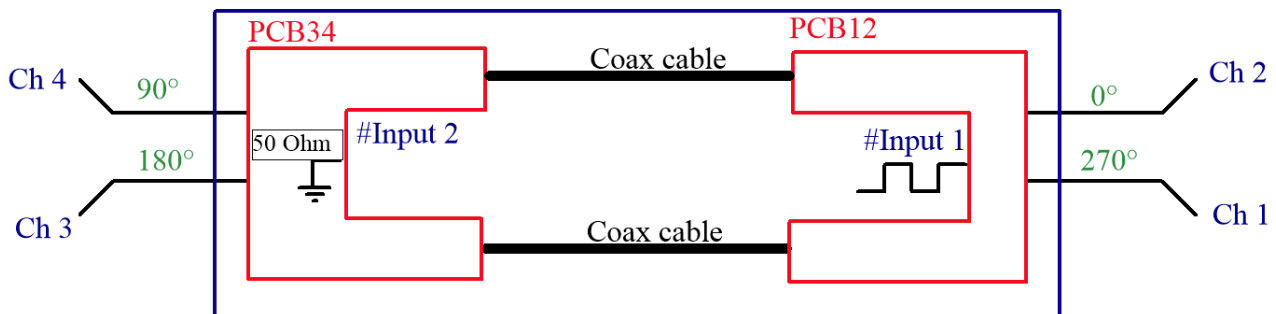


Figure 2 6U structure from the top, 2U side. Input signal at Input 2 and detection at Ch2, Ch1, Ch3 and Ch4. Green numbers are the expected relative phase of the received signal in degrees at each channel (by taking channel 2 as a reference as an example). Each channel corresponds to an antenna rod.

3.3 Mode 3

The RF modules connects to input 1 and 2. Depending on the usage of input 1 or input 2, right-hand or left-hand circular polarization applies respectively. Only one of the inputs can be used at a time. This mode follows both the black pathway and the blue pathway on the block diagram. Terminate any unused port in this mode, input 2 or input 2.

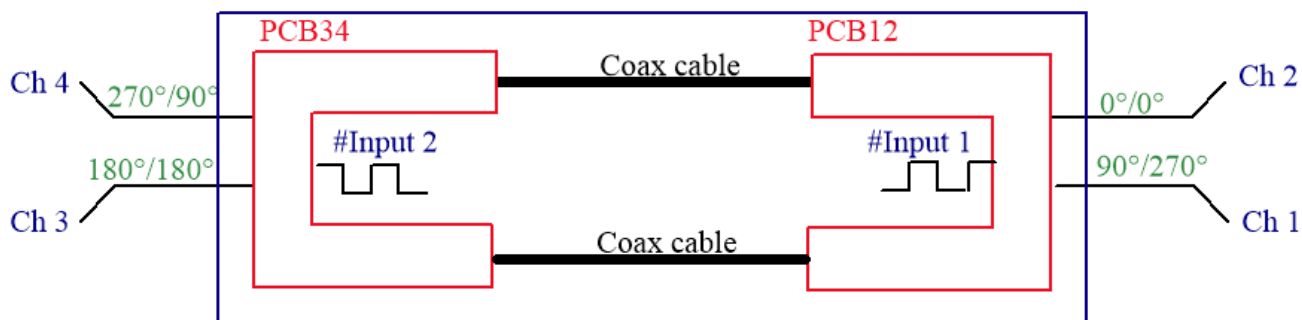


Figure 3 6U structure from the top, 2U side. Input signal at Input 1 or Input 2 and detection at Ch2, Ch1, Ch3 and Ch4. Greens number are the expected relative phase of the received signal in degrees at each channel (by taking channel 2 as a reference as an example). Each channel corresponds to an antenna rod.

Due to the tumbling of the satellite and changes in pointing direction of the satellite toward the ground station, which results in changes from RHCP and LHCP, the GomSpace UHF ground station is designed as a dual linear polarized antenna and therefore can receive the RF signal with 3dB loss regardless of LHCP or RHCP. 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).

4 Antenna Deployment

The antenna release system is similar to what is used in previous GomSpace products (NanoUtil Interstage GSSB). This system has flown in several missions and deployed successfully every time.

Every UHF antenna rod is 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 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

4.1 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. It is important to notice that this release mechanism used by GomSpace ensures the communication even when the release process fail since the antenna are fully exposed to the space.

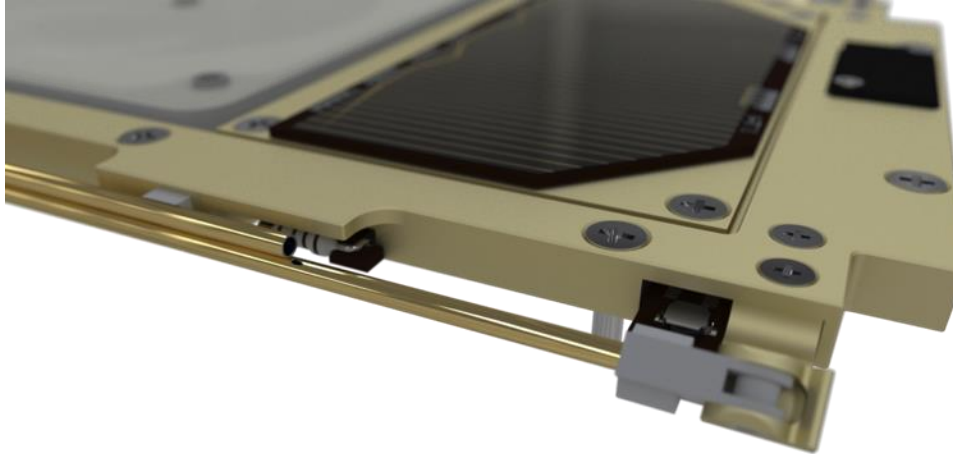


Figure 4, Detail of the antenna release mechanism showing the resistor and the hinge where the antenna is mounted and in stowed position.

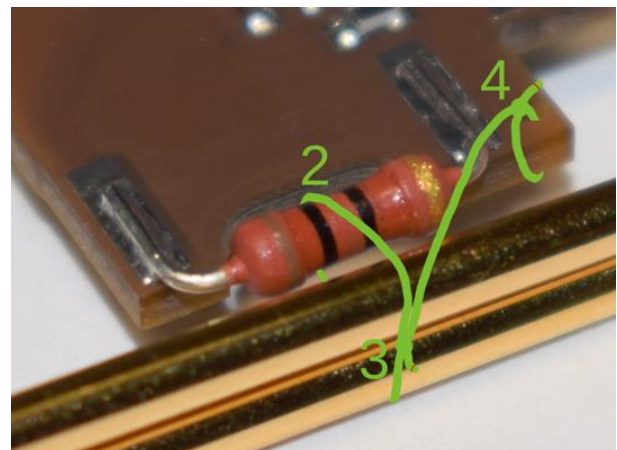
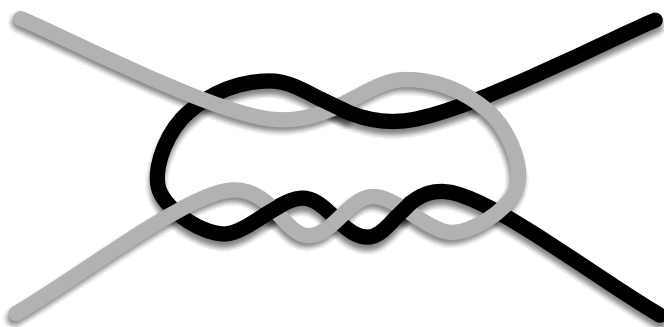
The monofilament can be easily replaced and, therefore, the antenna release can be tested before launch for every mission checking the proper behaviour.

4.2 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 of the antennas 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 debris).
5. Use a knife or scissor to remove the remaining wire after the knot

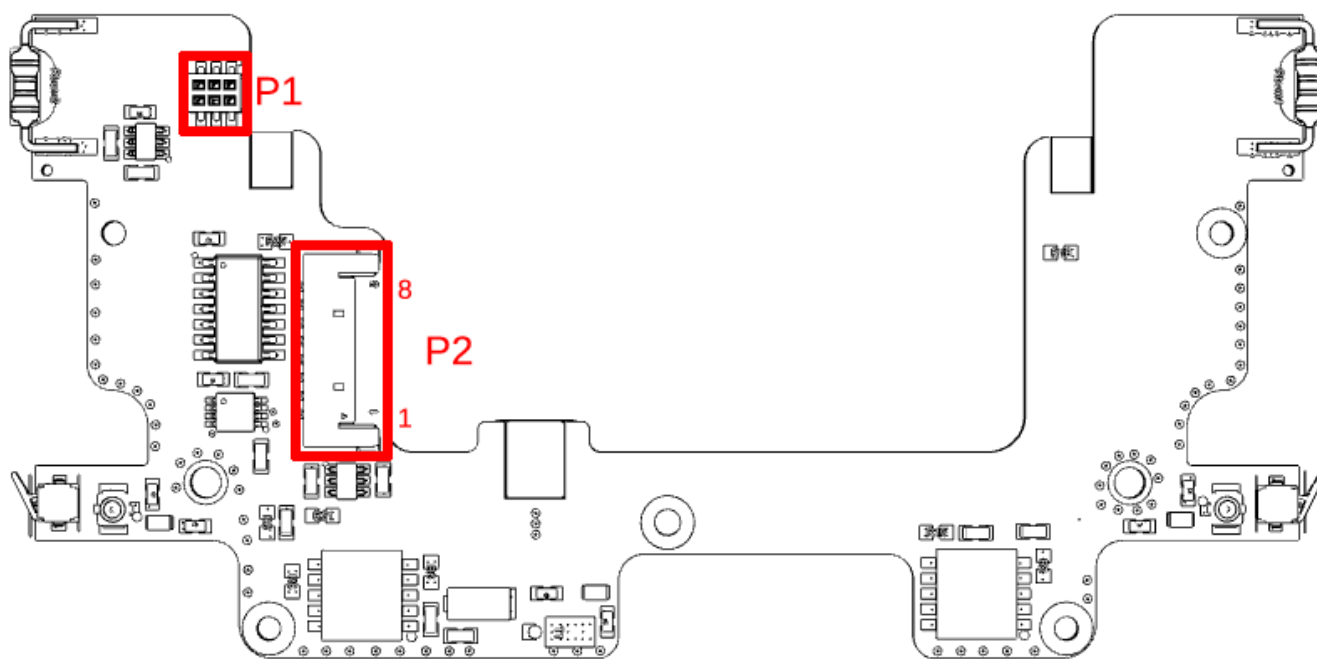
Surgeons Knot



5 Hardware Layout, Connectors and Pin Out

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

5.1 ANT-6F UHF Top



5.1.1 P1 – External Programmer

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

5.1.2 P2 – GomSpace Release Bus (GSRB) Connector

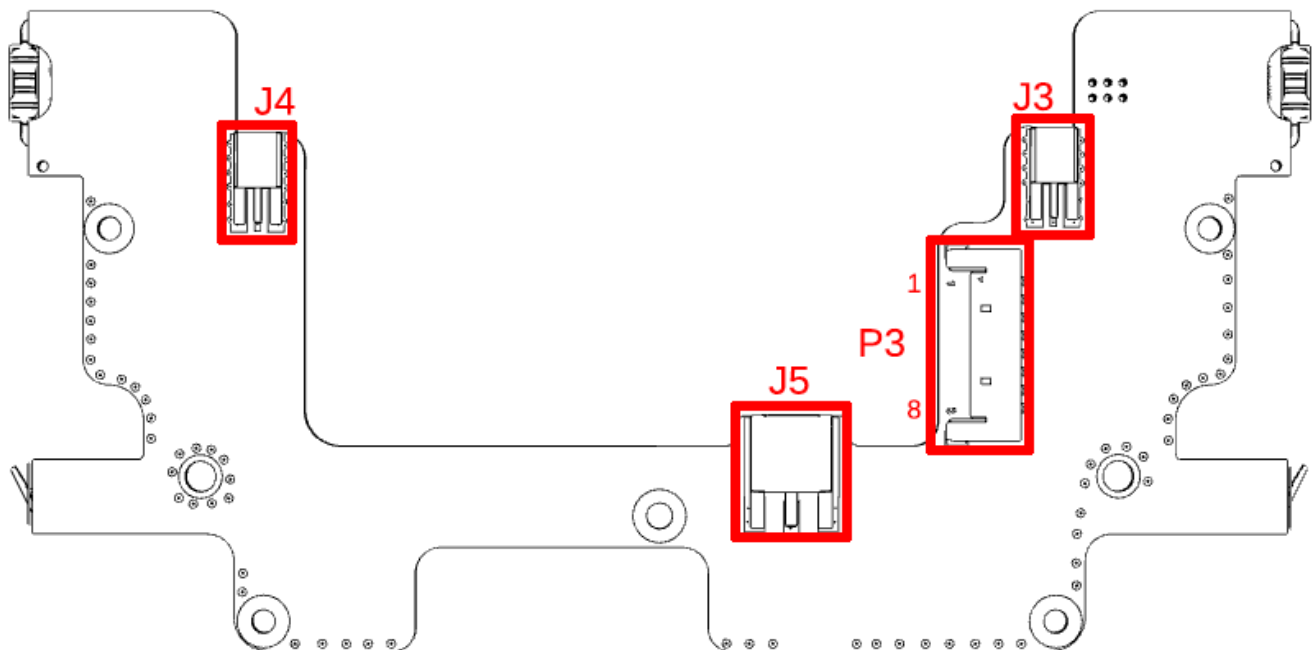
Molex Pico-Lock 504050-0891.

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	Burn_GND
2	Burn_GND
3	Burn_VDD
4	Burn_VDD
5	GND
6	GSSB_VCC
7	GSSB_SCL
8	GSSB_SDA

Important Note: For better grounding of the high current through the PCBs, there is separate ground associated for the burn signals on the antenna boards and on the NanoPower P60 side. Make sure to share the GND and Burn_GND while testing.

5.2 ANT-6F UHF Bottom



5.2.1 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	Burn_GND
8	Burn_GND

Important Note: For better grounding of the high current through the PCBs, there is separate ground associated for the burn signals on the antenna boards and also on the NanoPower P60 side. Make sure to share the GND and Burn_GND while testing.

5.2.2 J5 - MCX RF Connector

The RF connector is a 50 Ω MCX for edge mounting. It works well with two right-angle connectors on a 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 5 MCX connector and mating cable from Molex

5.2.3 J3/J4 - SMPM RF Connector

The RF connector is a 50 Ω SMPM for PCB edge mounting.

The two PCBs, top and bottom, are interconnected using RG-178 based coax cables with a SMPM straight plug at each end. Note: the length of the coax cables is optimized to provide a certain phase-delay. They should not be interchanged.



Figure 6 SMPM connector

5.3 Connection to the Antenna Rods

The PCB's are connected to the antenna rods through an U.FL-LP-040 connector, located near the antenna deployment detector mechanism. The antenna elements are all grounded via a resistor at their connection point, U.FL-LP-040 connector, to the PCBs to avoid electrostatic discharge in the satellite.

6 Data Interface – Antenna Deployment

The NanoCom ANT-6F UHF uses I²C communication. It is driven in I²C slave mode, and the default address is 0x05 and 0x06. It has to 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.

7 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	3.2	3.4	V
BURN B1	Burn resistor voltage	4.5	7	V
I_BURN	Current over burn resistor	0.4	1	A
t_BURN¹	Total burn time of each burn resistor		20	s
n_BURN¹	number of activation times of each burn resistor		5	

8 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	7	V
I_BURN	Current over burn resistor	0.4	0.5	1	A

9 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	400	405	MHz
Frequency range for ANT-6F-M		430	435	440	MHz
Frequency range for ANT-6F-H		465	470	475	MHz
Temperature range		-40	-	85	°C

*For higher output power contact GomSpace

10 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

11 Antenna Performance

11.1 Polarization

The antenna is circular polarized. Depending on which antenna PCB connects to a receiver, seen from top can be left hand or right hand circular polarization. The same applies for the bottom side. (See chapter 3)

11.2 Antenna Feed Network

The antenna is designed with the goal of avoiding dead spots in the radiation pattern making it close to omnidirectional by feeding the antenna ports via a feed network. Purpose of the feed network is to divide the input signal to the four ports with equal amplitude (ideally -6dB compared to input signal) and with the correct phase as shown in figure 1-3. There is a loss and offset in gain and phase from desired values due to the loss and tolerances in the selected feed network, therefore the relative gain and phase for all antenna ports shown below, while it is measured using a RF network analyzer at GomSpace facilities. The measurement has been done while the ANT-6F is mounted on a 6U structure, so it is as close as possible to a real case.

The transmission signal is on Input 1 or Input 2 (the feeding points) and the reception is at all the channels. Channels correspond to antenna's connectors (U.FL connectors) with the same numbering convention as Figure 1. Feeding signal at Input 1, results in generating the output signals with relatively 90-degree phase shift between all the channels as illustrated in the block diagram in chapter 2.2.

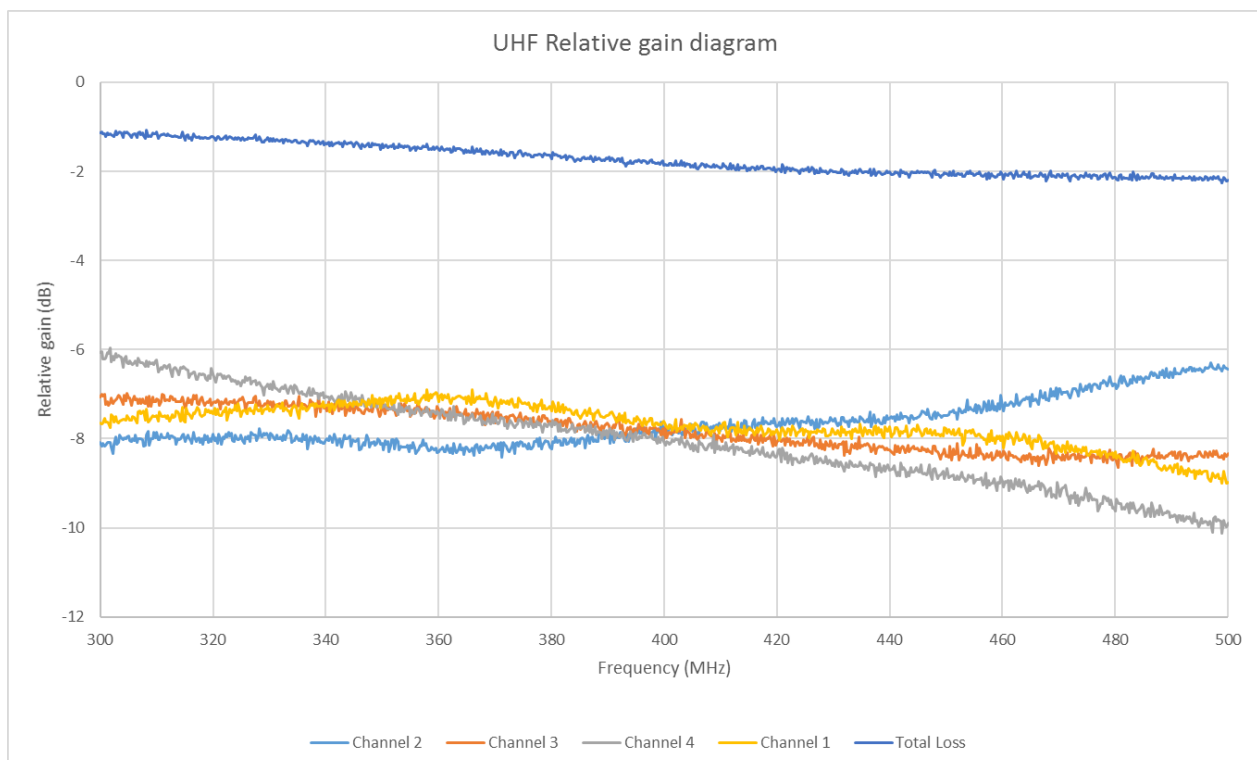


Figure 7 Signal has been sent at Input 1 and each color corresponds to the measured signal at different channels - U.FL antenna connectors. This is the measured gain due to the loss in the PCBs and coax cables for the configured device at 400MHz operation frequency.

From the Fig. 7, we can conclude that the relative gain for each of the four antenna ports is within -7 dB and -9.5 dB for frequency range of 340-680 MHz. As expected from the couplers functionality, the gain is highest and similar in all the channels in the central frequency. For example, at 400 MHz, the relative gain is between -7.5 dB to -8 dB for each channel, and adding the signals at each of the four antenna ports results in a total loss of around 2dB for the complete feed network, which is acceptable.

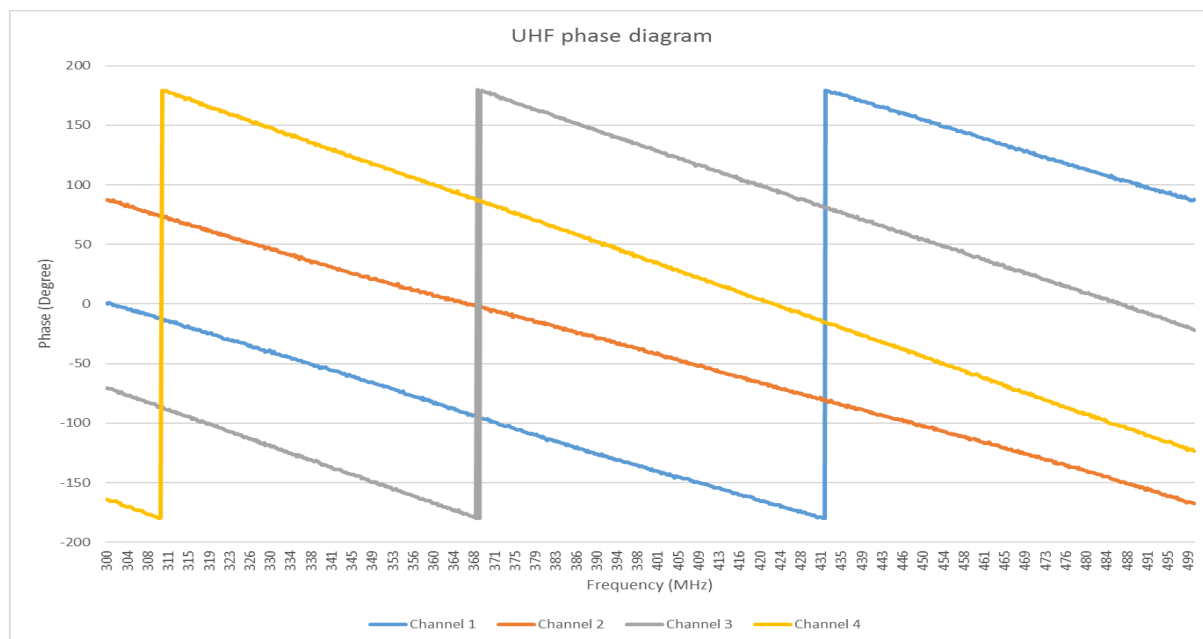


Figure 8 Signal has been sent at Input 1 and each color corresponds to the measured signal at different channels - U.FL antenna connectors. This is the absolute phase measured via network analyzer.

The antenna module includes connectors and matching circuit and has four antenna ports which must be driven by about 90° out of phase to generate a circular polarized radiation. In Fig. 8 for each certain frequency the phase difference between each channel is measured and illustrated. As expected they are close to 90° for the centre frequency and deviate slightly on the higher frequencies. The deviation of phases from ideal 90° phase difference had negligible effect on the output gain (less than 0.3 dB).

11.3 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 illustrated in Cartesian and Spherical coordinate systems in Fig. 9.

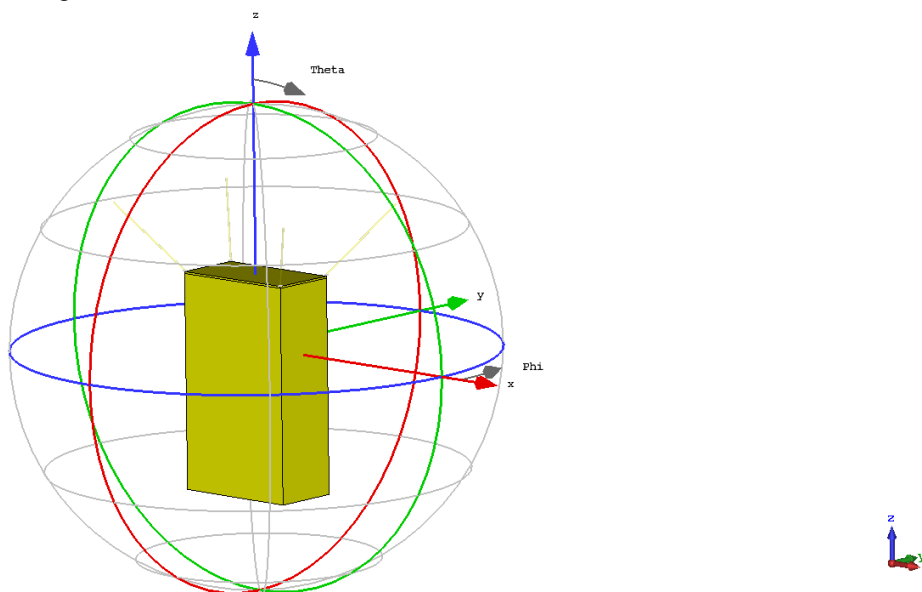


Figure 9 Satellite coordinate system illustration in Cartesian and Spherical coordinates.

The actual gain characteristics depend on the shape of the spacecraft and its deployable structures. For a GomSpace GOMX4 satellite, which does not have any deployable system, the results for the measured gain from Satimo System is shown both in linear and polar coordinates under Fig. 10 to Fig. 13. The performance is limited mainly by the compact antenna size and the loss in the feed network. The measured results illustrated below include all losses from all the antenna ports.

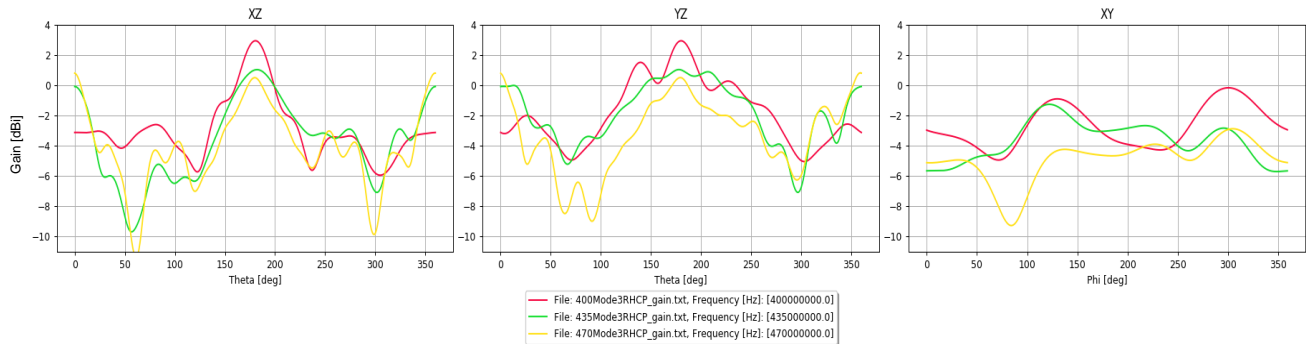


Figure 10 Farfield realized gain measured in the Satimo System for 400MHz, 435MHz and 470MHz variants in RHCP. The illustration shown linearly in three different orientations.

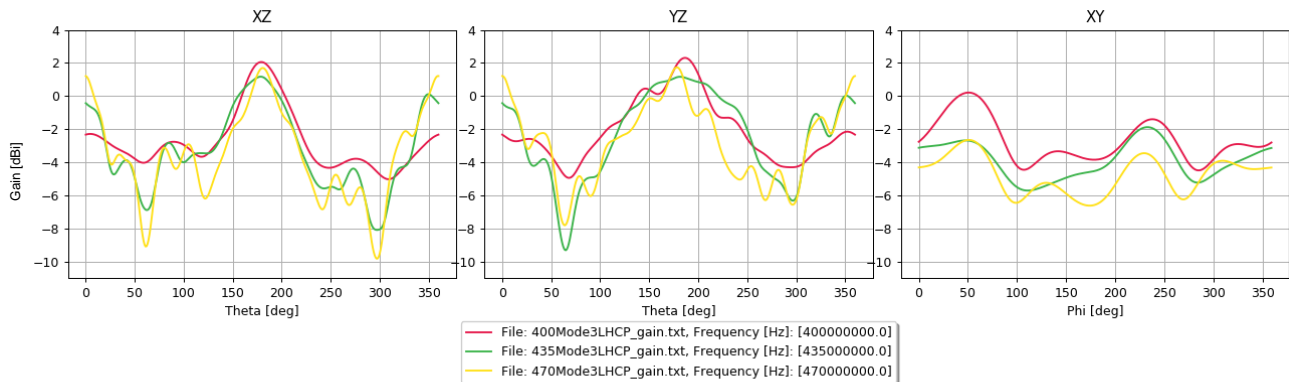


Figure 101 Total farfield realized gain measured in the Satimo System for 400MHz 435MHz and 470MHz variants in LHCP. The illustration shown linearly in three different orientations.

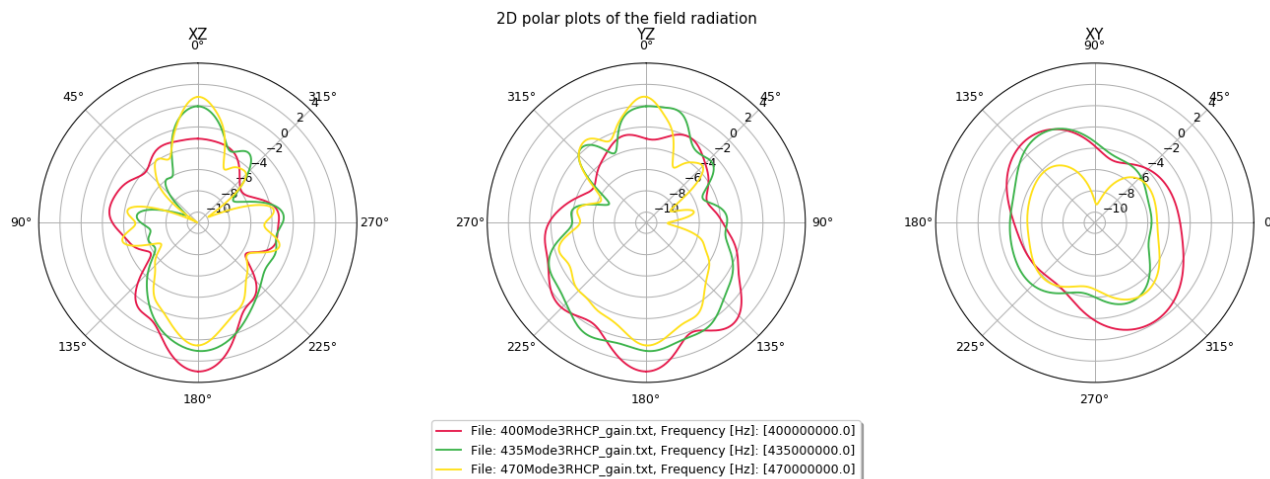


Figure 12 Total farfield realized gain measured in dBi in the Satimo System for 400MHz 435MHz and 470MHz variants in RHCP. The illustration shown in Polar coordinate in three different orientations.

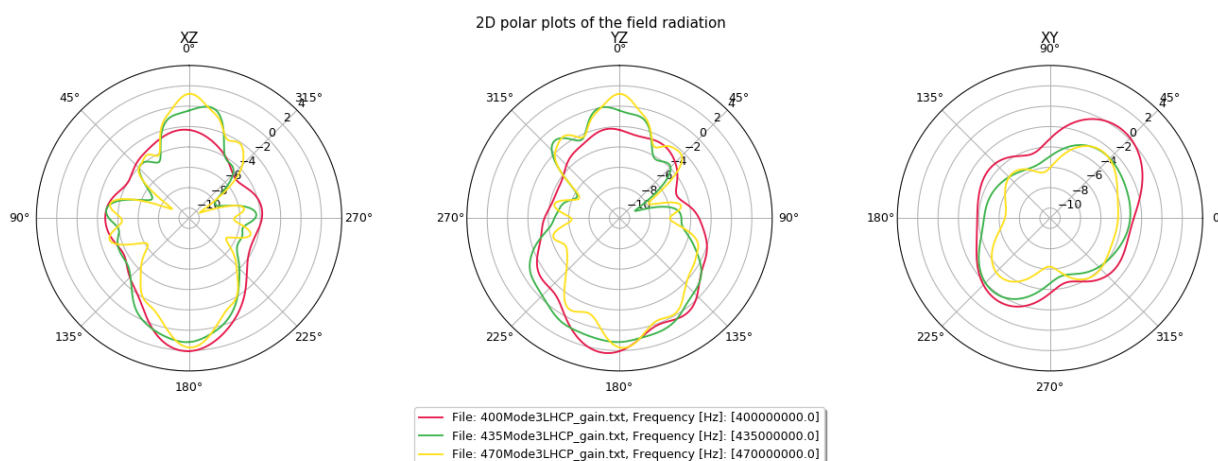
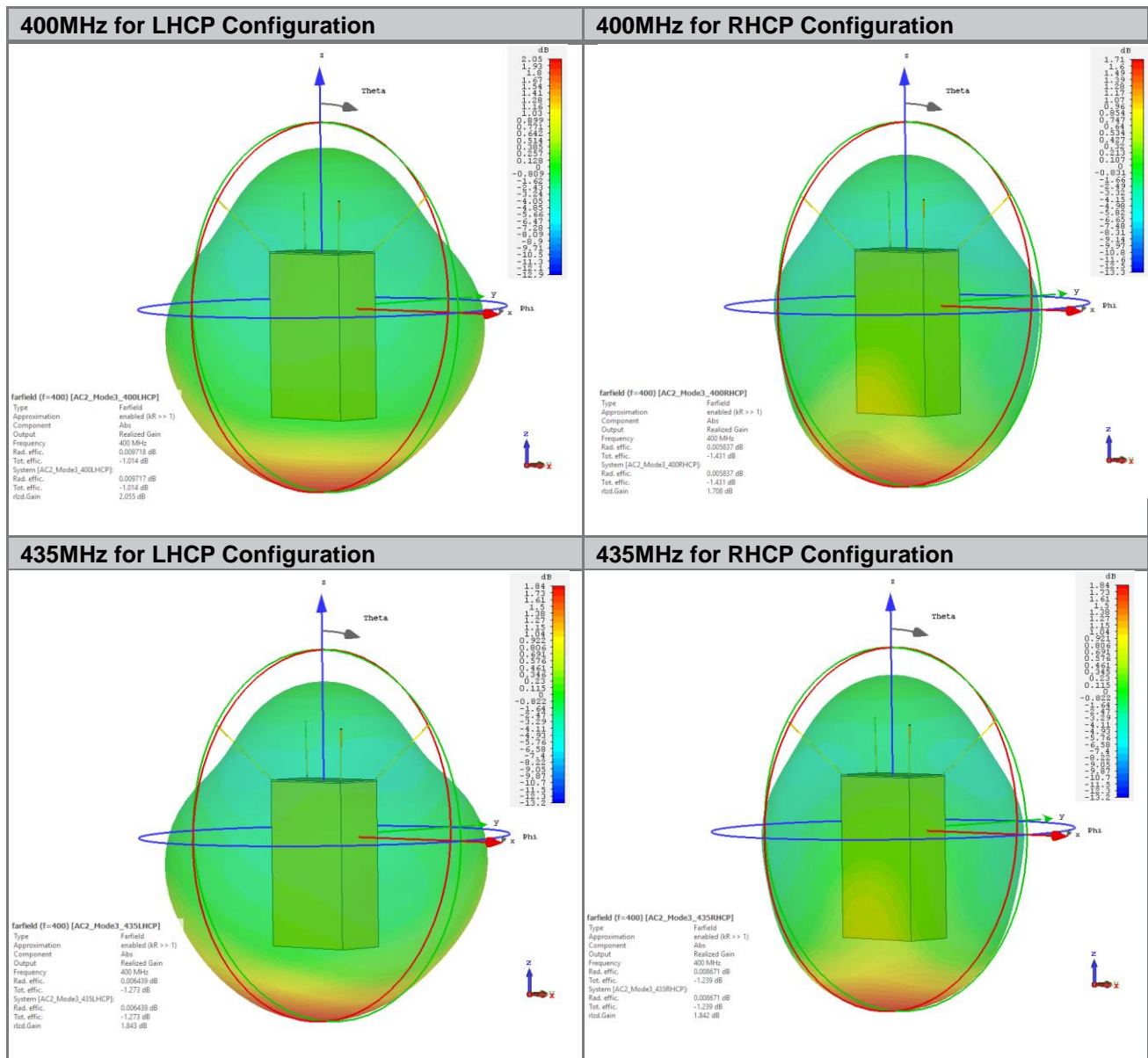


Figure 13 Total farfield realized gain measured in dBi in the Satimo System for 400MHz 435MHz and 470MHz variants in LHCP. The illustration shown in Polar coordinate in three different orientations.

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 total Farfield realized gain in dBi in 3D view, independent of the polarisation (RHCP or LHCP) for all the three variants. The phase mismatch is included in the simulation.



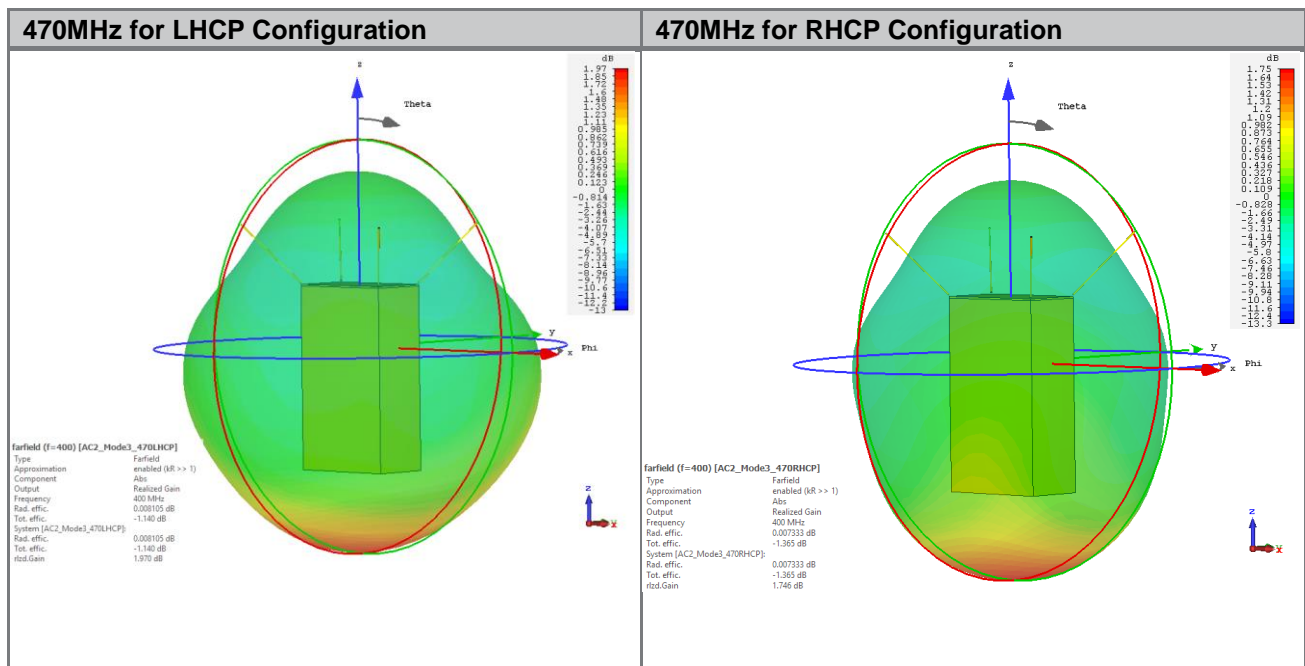


Figure 14 Total farfield realized gain in 3D view simulated using CST software.

As can be seen in the above figures, the highest gain (2.05 dB for 400MHz in RHCP variant) is along the long Z-axis 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.

11.4 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.

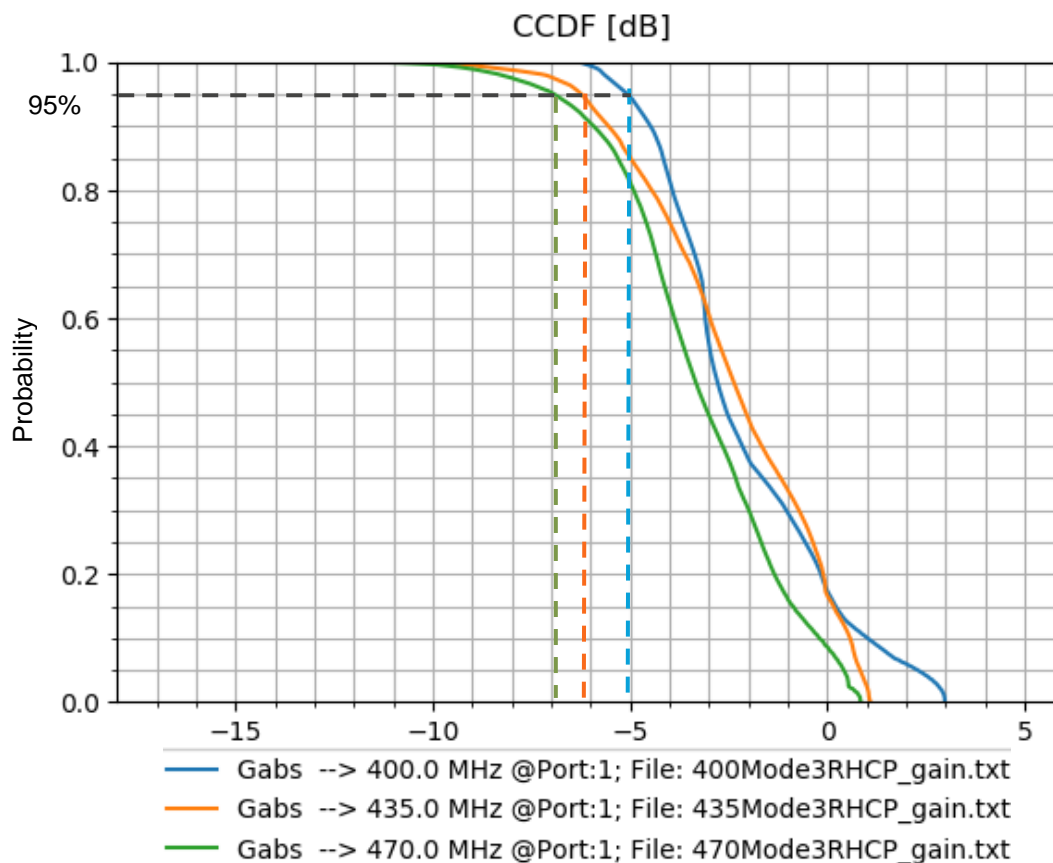


Figure 15 Absolute Gain Probability in dBi for RHCP configuration

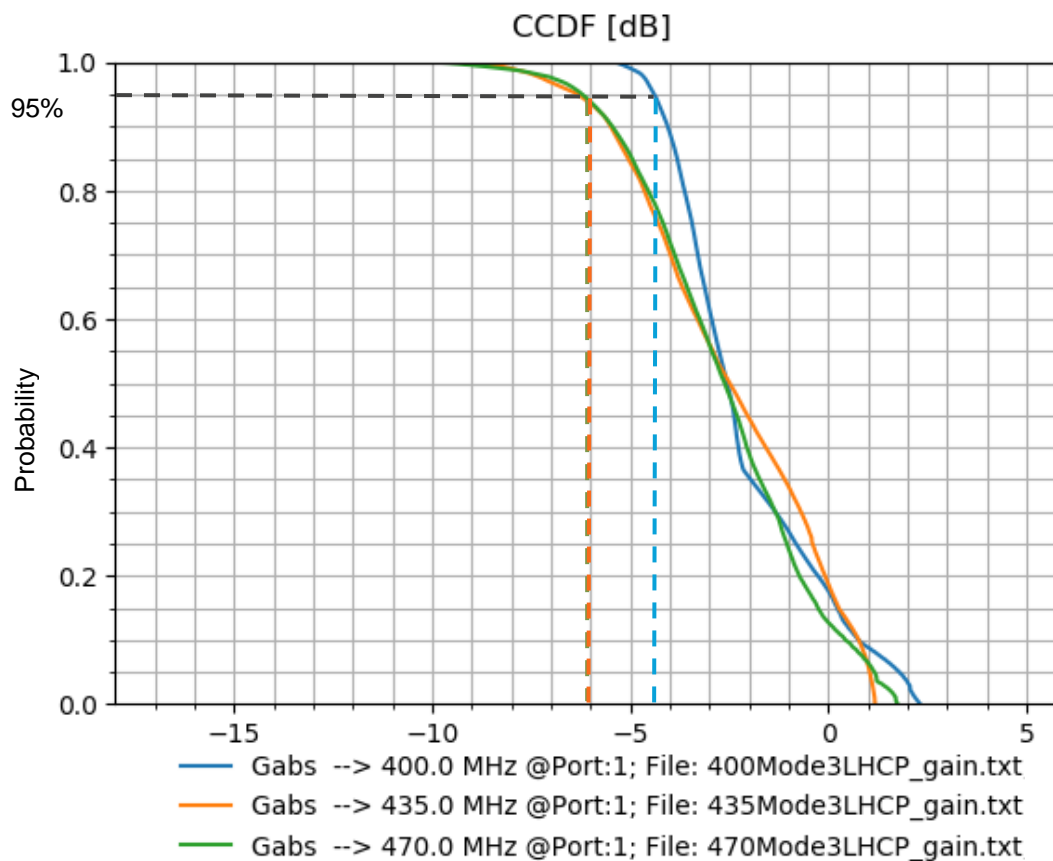


Figure 16 Absolute Gain Probability in dBi for LHCP configuration

11.5 Port matching

The antenna elements are all matched to $50\ \Omega$ with on-board Pi-section matching networks individually. The antenna impedance after matching for one of the antenna elements illustrated in a smith chart in Fig. 15 and the magnitude illustrated in Fig. 16 in dB.

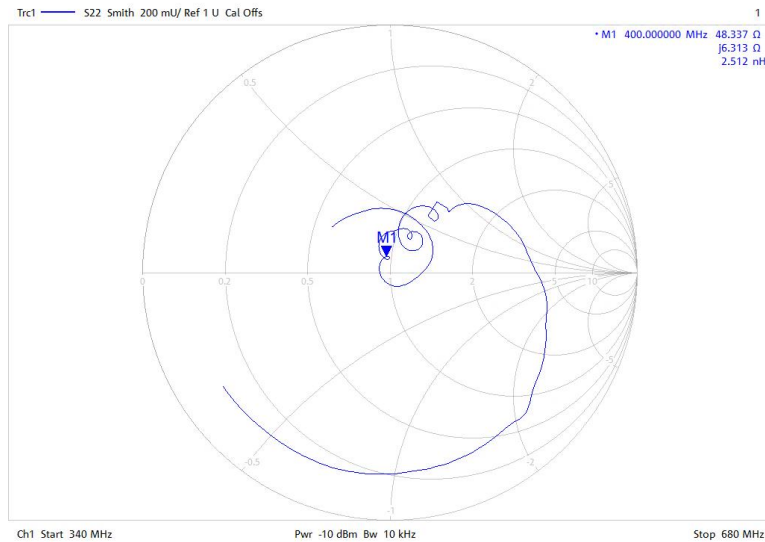


Figure 16 Smith illustration of impedance measurement at one of the antenna ports, with antenna rods and with matching components mounted on the other ports. Also, the full system installed on a 6U structure for more realistic results.

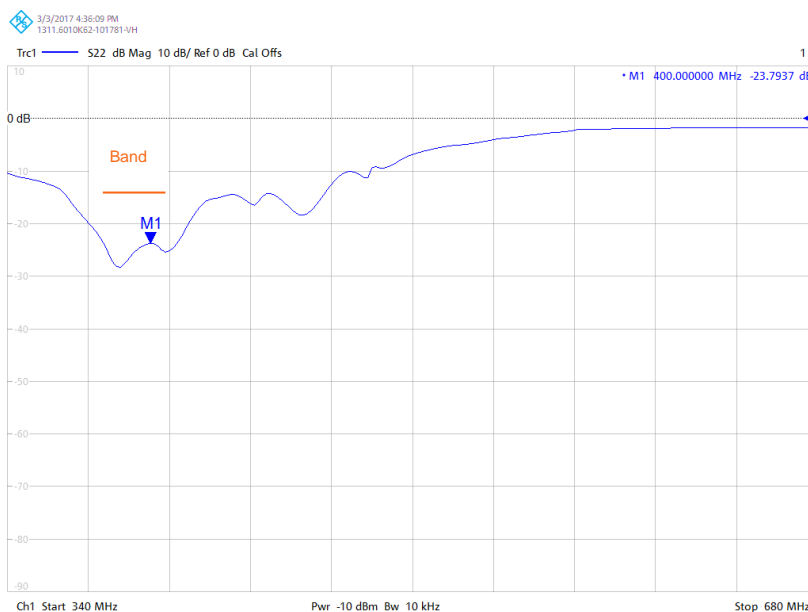


Figure 17 Magnitude illustration of one of the antenna ports with antenna rods and with matching components mounted on the other ports. Also, the full system installed on a 6U structure for more realistic results.

11.6 Input port Isolation

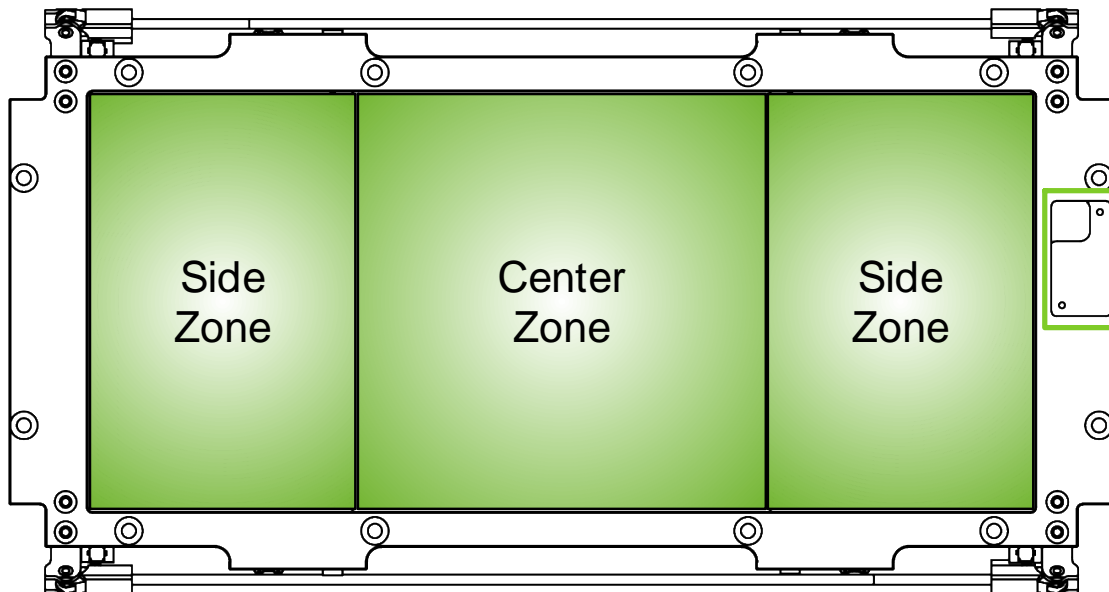
The isolation between the two RF ports on the Ant6F- UHF is 15dB and there is no protection circuit on the antenna board and it depends on the chosen transceiver. In the case of using AX100 as a transceiver, transmitting 30dBm on one port for example will result in about 15dBm on the other port. As long as 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 15dBm 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 Ant6F at the same time.

In the case of reception, there will be no issue to receive a low signal (in the order of -100dBm) 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. As I mentioned earlier, the 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.

12 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 a 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 sales person.

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 aluminum plates covering the three zones. Customer mounts their ordered zone options themselves.

13 Frequency Variants

The ANT-6F UHF comes in several variants. The difference is in the RF match and 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

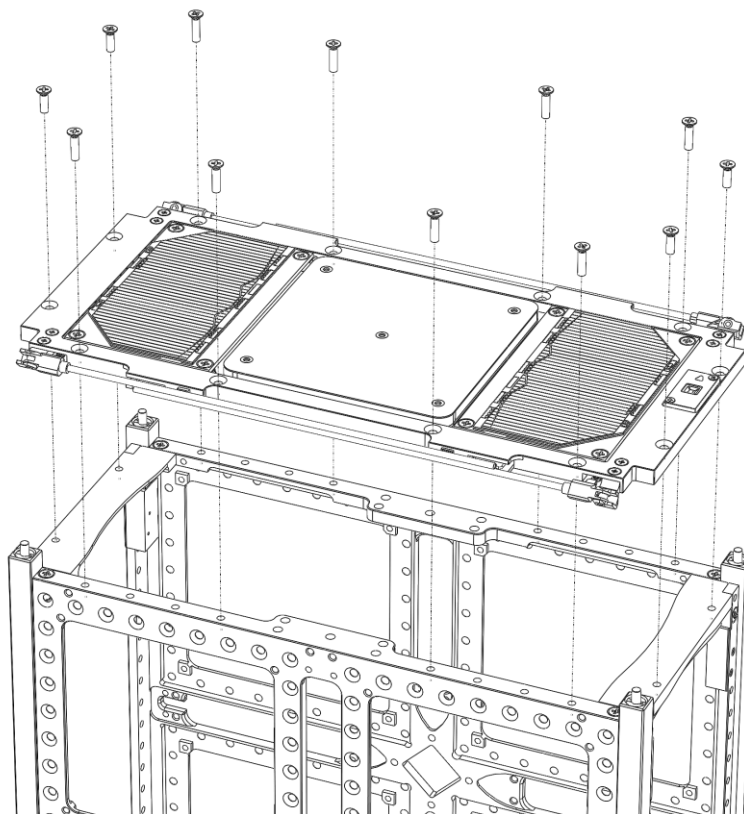
14 Environmental test

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

15 Integration

The mounting bracket is premounted 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.



16 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.

16.1 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.

16.2 Redundant Radios

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

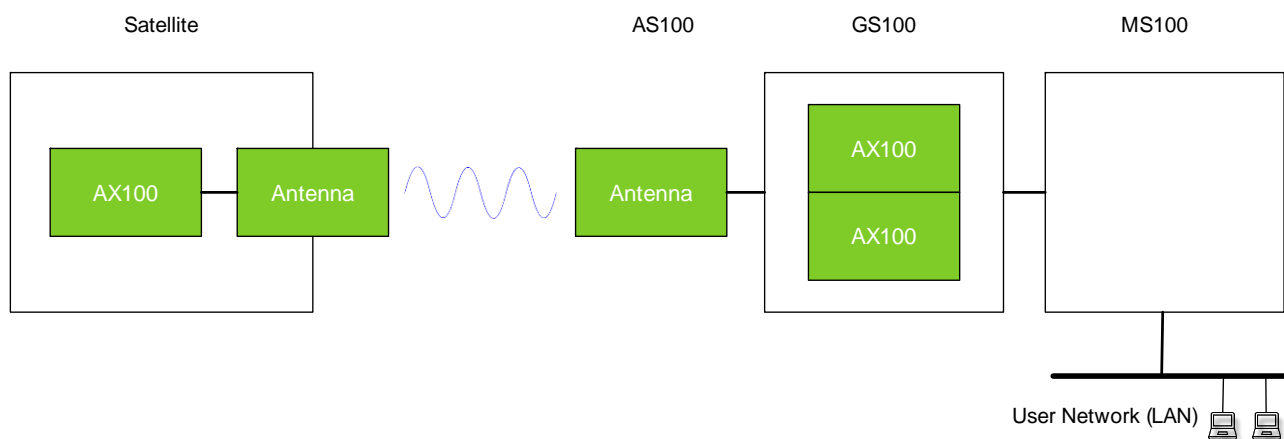
By connecting two AX100 for example to ANT-6F UHF, cold redundant AX100 radios would be controlled by the OBC or another system by simply switching the power to the AX100's off and on. In cold redundant mode, only one out of the two radios can be switched on at a time, and they share exactly the same 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.

16.3 GomSpace Ground Unit

GomSpace has a complete ground unit system with antenna (AS100), radio unit (GS100) and a computer (MS100) with software to access and run a complete satellite mission.

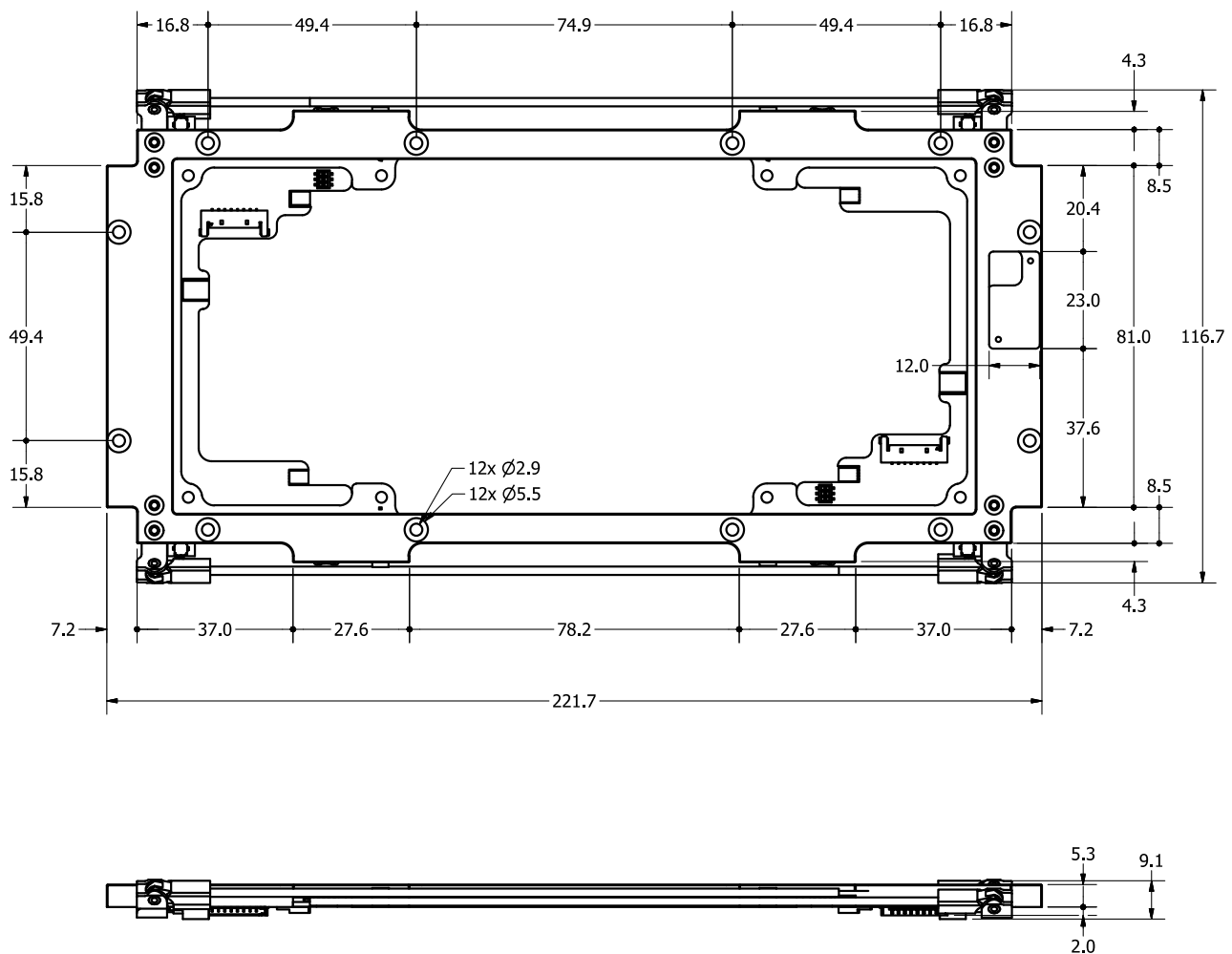
The GS100 is a 19" rack mounted unit that contains two NanoCom AX100 compatible radio units and hence delivers the optimal solution. The unit ensures that no matter which polarization is optimal, one of the radios will be listening. Also, it improves the G-T of the ground station, because the insertion loss of the polarization switch is avoided.



See the individual datasheets for further information.

17 Mechanical Drawing

All dimensions in mm.



18 Disclaimer

The information in this document is subject to change without notice and should not be construed as a commitment by GomSpace. GomSpace assumes no responsibility for any errors that may appear in this document.

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