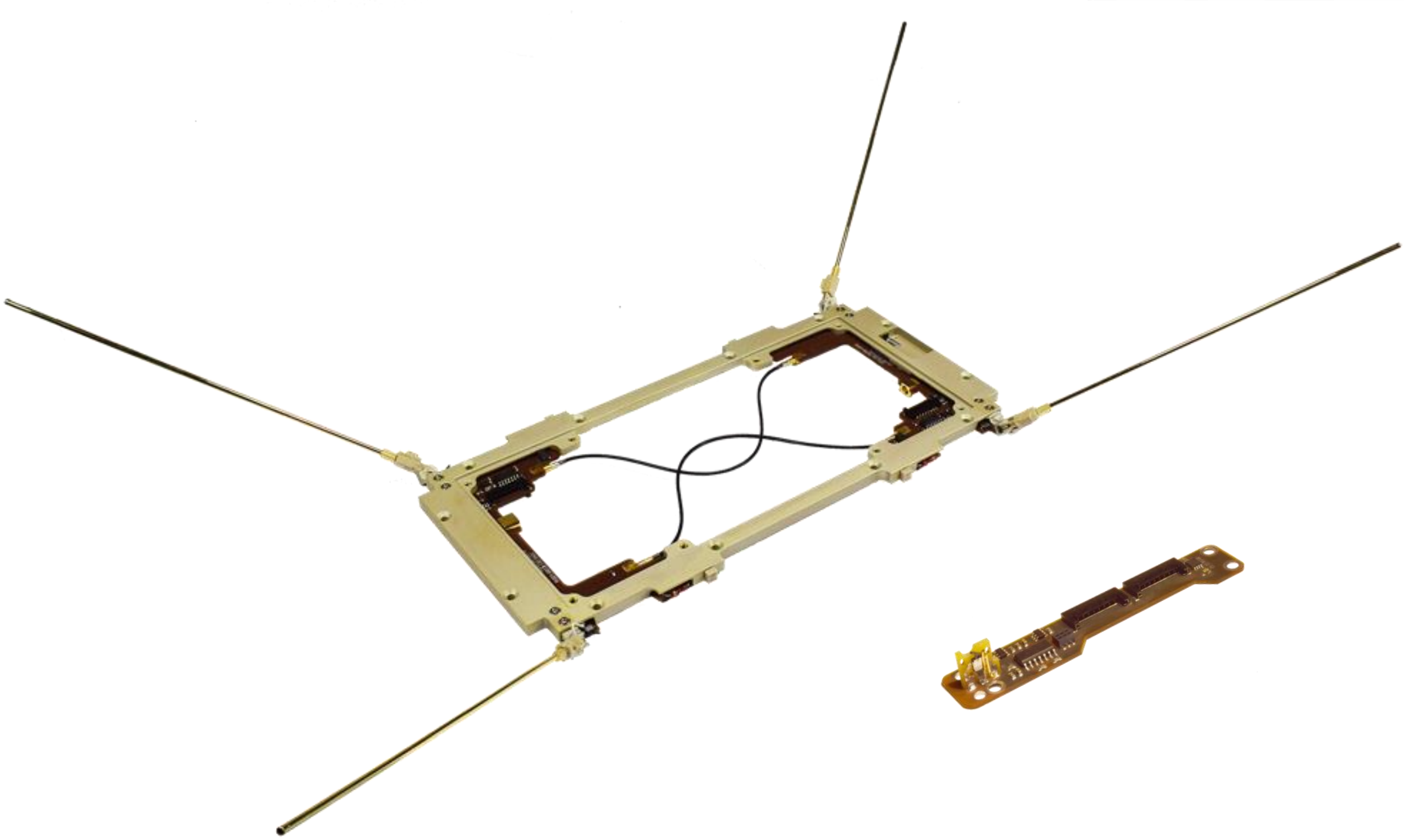

NanoCom
ANT-6F VHF

NanoUtil
AR6

Datasheet
VHF antenna and release system for GomSpace 6U structure

Product name: NanoCom ANT-6F VHF

Document No.: 1010858

Revision: 1.8

Author: ROBB

Approved by: JBJ

Approval date: 07 May 2020

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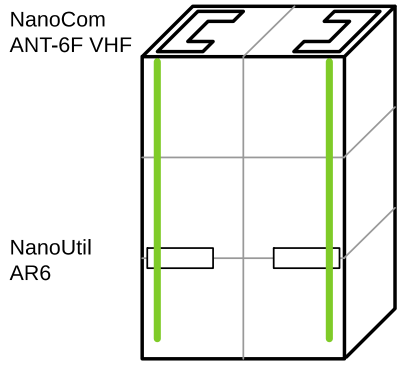
1 Table of Contents

2 Introduction

The complete GomSpace NanoCom ANT-6F VHF system contains an antenna system mounted on top the GomSpace 6U structure and an antenna release system (AR6) mounted on the side of the structure.

When the satellite is stored in a launch pod the antenna rods are stowed down the side. After release, the AR6 can burn through a wire and the rods will deploy upwards



The ANT-6F VHF is described from chapter 3 through 18, and the AR6 is described in chapters 19 to 27.

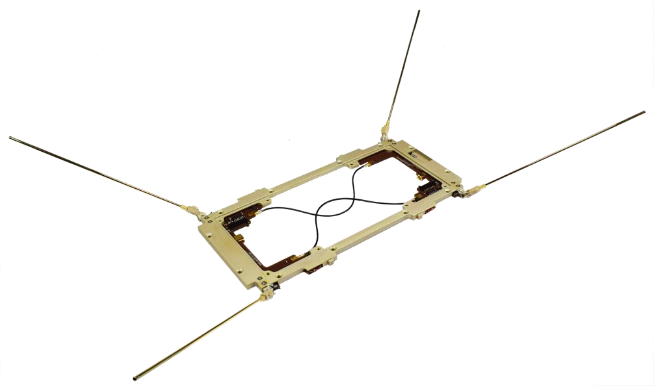


Figure 1 ANT-6F VHF

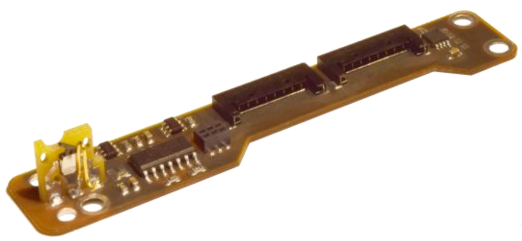


Figure 2 AR6

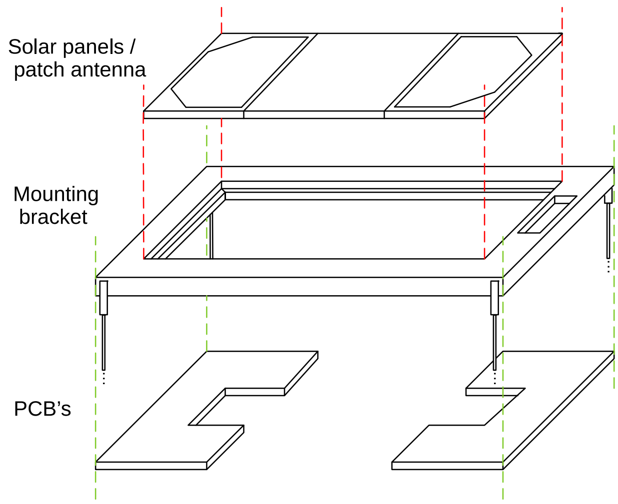
3 Overview ANT-6F VHF

The GomSpace NanoCom ANT-6F VHF antenna for the VHF band (130 MHz - 210 MHz) is a deployable, omnidirectional and canted turnstile antenna system with rigid antenna elements, which eliminates the risk of antenna deformation while stowed. Dual pole 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 pole design, it provides redundancy in RF communication. There will be two possible connections to two RF transceivers (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 UHF can be mounted, and in the other end a VHF version can be mounted.



ANT-6F VHF is made of three layers screwed (with helicoils) together:

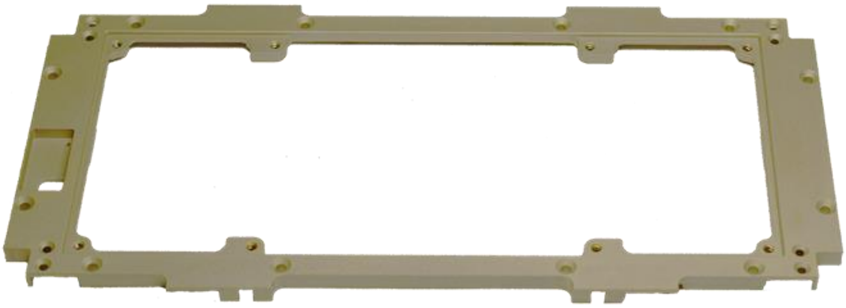
- The top layer is made of number of different modules depending on customer choices. Examples of choices can be: solar panels, patch antennas, camera, propulsion etc. These are ordered through their own option sheet.
- The middle layer is an aluminum-mounting bracket where the top and bottom layers are mounted on. Here are also mounted the four VHF antennas rods and a slot for a GomSpace Fine Sun Sensor (FSS).
- Bottom layer contains of two PCB's, which contains all the connectors and electronics

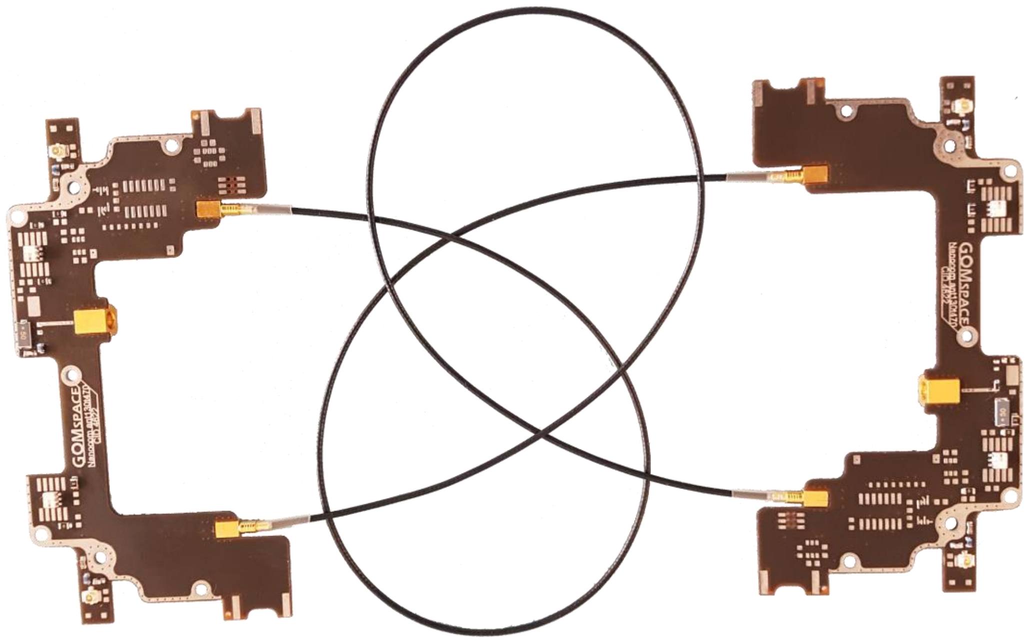
Note: ALL PICTURES SHOWN IN THE DATASHEET ARE FOR ILLUSTRATION PURPOSE ONLY. ACTUAL PRODUCT MAY VARY DUE TO PRODUCT ENHANCEMENT.

3.1 Highlighted Features

Fits GomSpace 6U structure

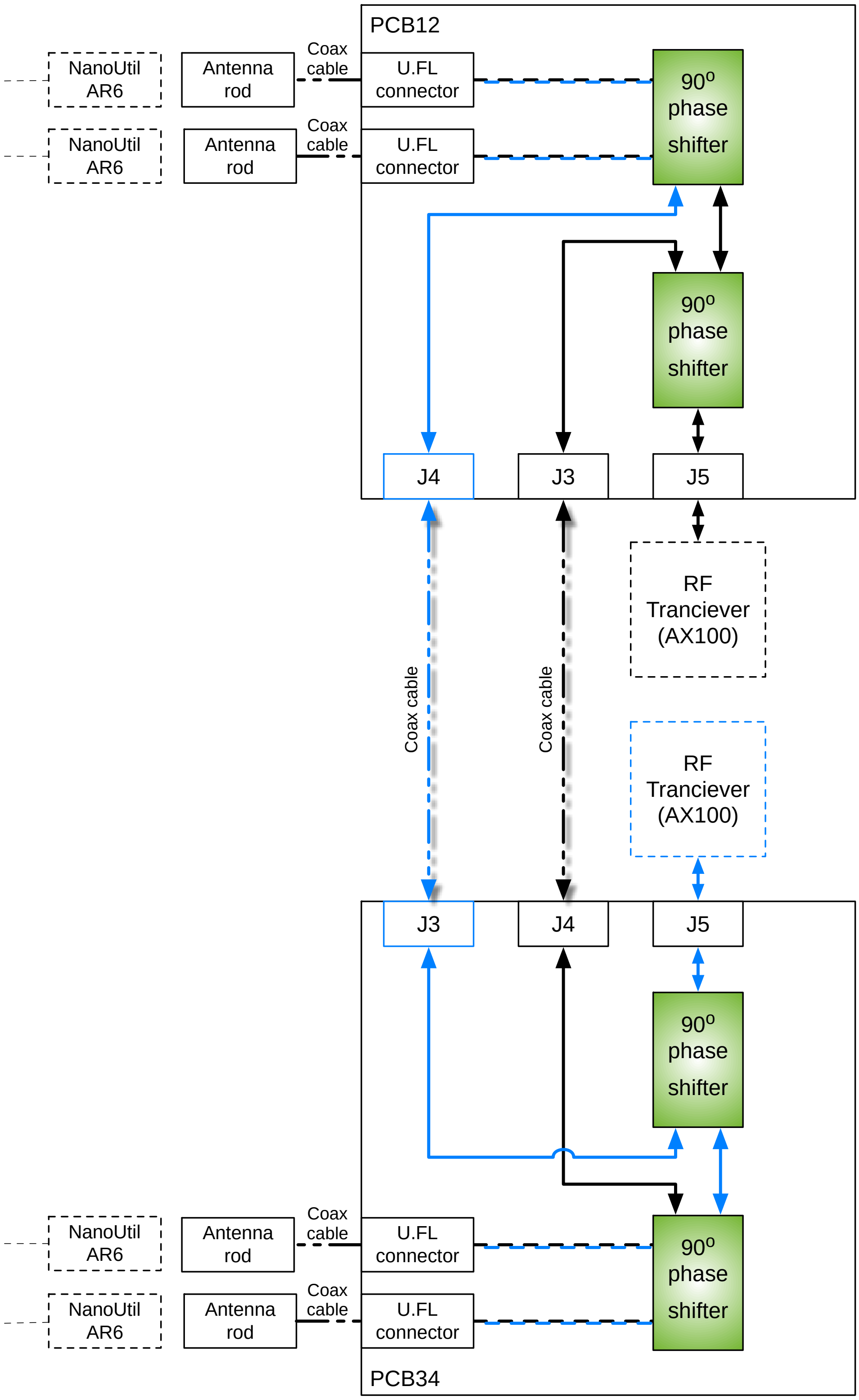
- Multiples of choices of top layer hardware
- Consists of two rigid PCBs connecting with a Coax cable with a fix length depending on the requested frequency
- Can be used together with GomSpace NanoCom ANT-6F UHF antenna on opposite side of the satellite.
- Dual pole design to provide redundancy in case of a transceiver failure
- Omnidirectional Canted Turnstile Antenna
- Frequency range: 130-210 MHz
- Max. gain: 0.8 dB at 161 MHz
- Rigid antenna tubes
- Safe antenna rod stowage system
- Matched to 50 Ω
- PCB material: Glass/Polyimide
- IPC-A-610 Class 3 assembly





3.2 Block Diagram

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



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

4 Mode of Operation

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 effects both phase and relative gain measurements.

4.1 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.

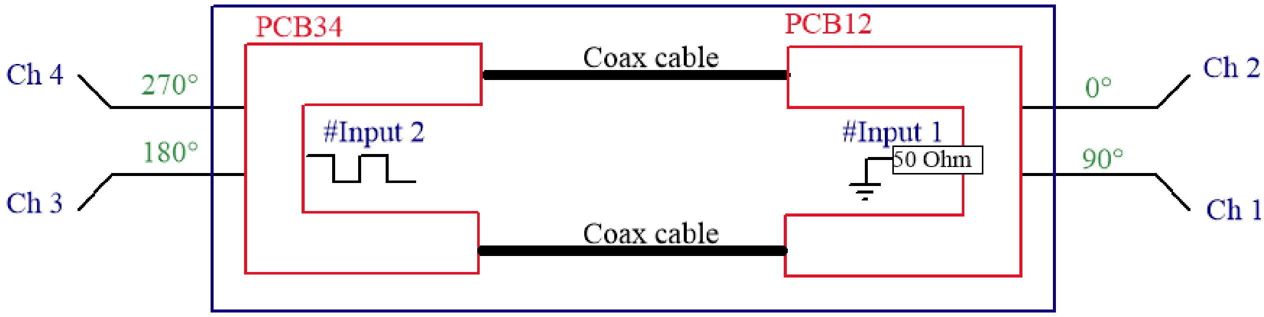


Figure 3 6U structure from the top, 2U side. Input signal at Input 1 and detection at Ch2, Ch1, Ch3 and Ch4. Green number are the expected phase of the received signal in degree at each channel. Each channel corresponds to an antenna rod.

4.2 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.

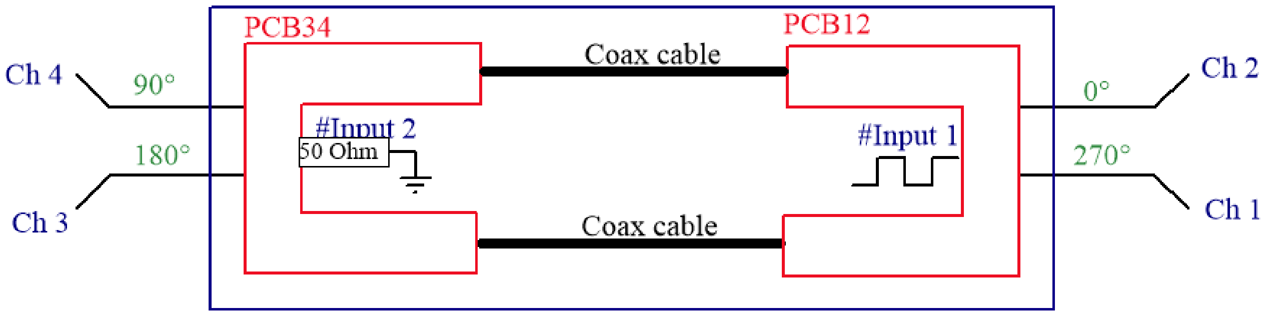


Figure 4 6U structure from the top, 2U side. Input signal at Input 2 and detection at Ch2, Ch1, Ch3 and Ch4. Green number are the expected phase of the received signal in degree at each channel. Each channel corresponds to an antenna rod.

4.3 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.

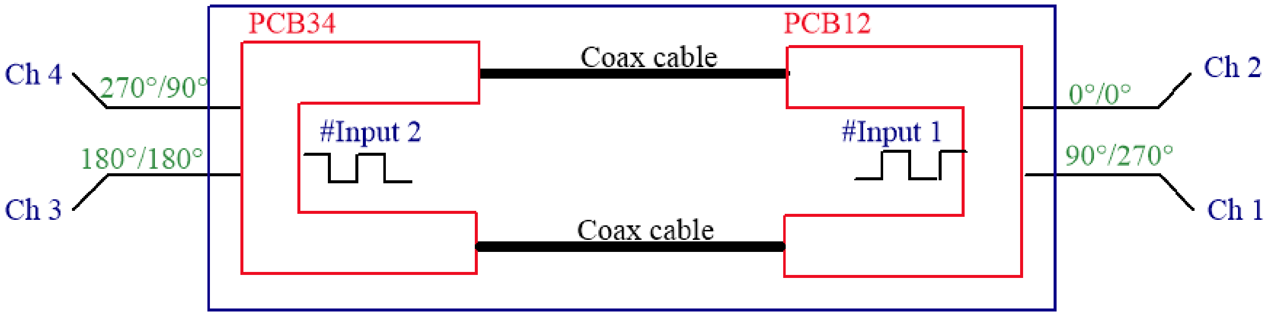


Figure 5 6U structure from the top, 2U side. Input signal at Input 1 or Input 2 and detection at Ch2, Ch1, Ch3 and Ch4. Green number are the expected phase of the received signal in degree at each channel. Each channel corresponds to an antenna rod.

5 Antenna Deployment

The ANT-6F VHF antenna deployment system works together with the NanoUtil AR6. The antenna rods are stowed down the side of the satellite and the AR6 system contains the release system.

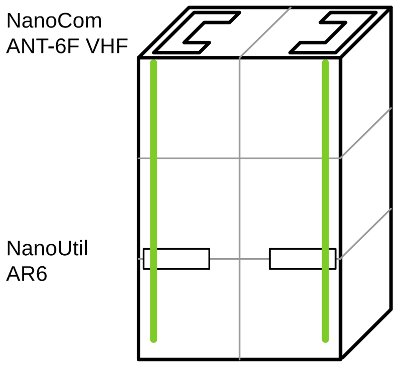


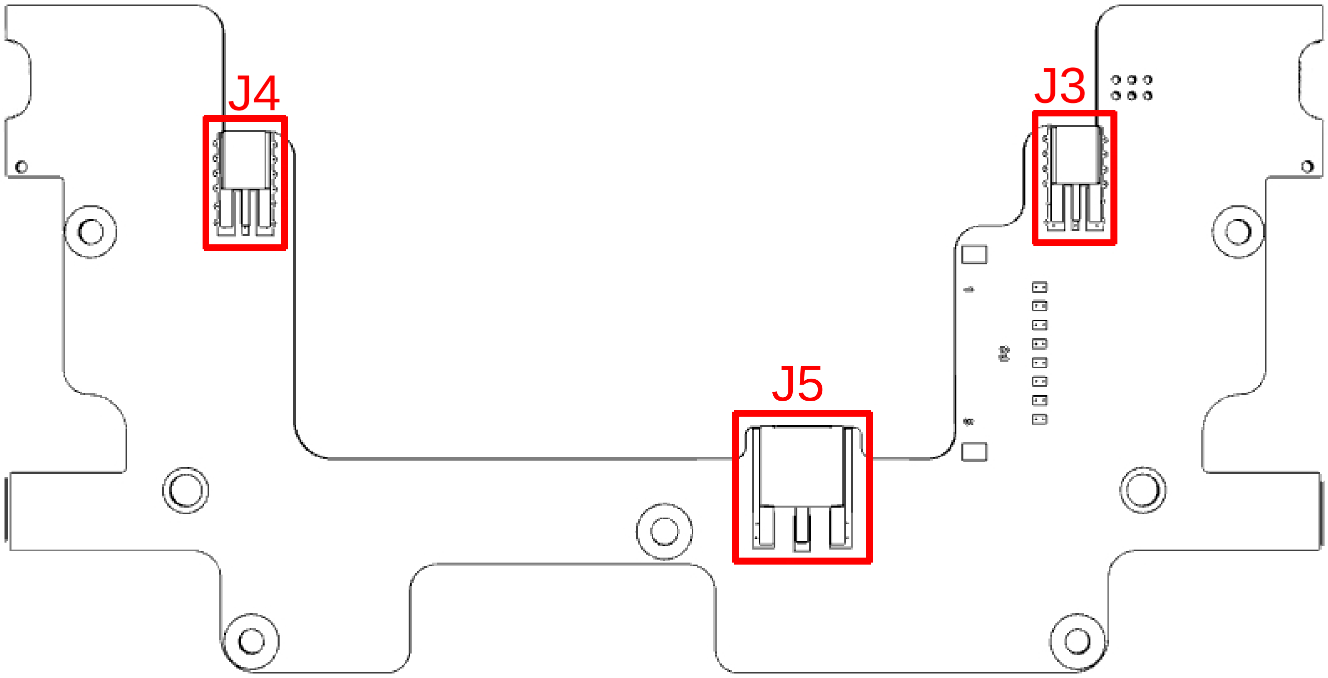
Figure 6 6U structure with mounted ANT-6F VHF on the top and AR6 on the side. Antenna rods (in green) stowed down the side

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 VHF antenna rod is mounted on a hinge affixed to an impedance matching mounting bracket. The hinges are made of aluminum and PEEK to prevent antenna element grounding. The antenna line is routed through the hinge axis to prevent stress accumulation during the deployment. 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 the reliable deployment.

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

6 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 the same.



6.1 ANT-6F VHF Bottom

6.1.1 J3/J4 - SMPM RF Connector

The RF connector is a 50 Ω SMPM for 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.

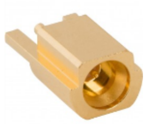


Figure 7 SMPM connector

6.1.2 J5 - MCX RF Connector

The RF connector is a 50 Ω MCX for edge mounting. It works well with a right-angle connector on a RG316 or RG178 cable on one end and left-angle connector on the other end to connect to a transceiver. Note: The cables made with space-proof heat-shrink tubing to avoid outgassing in vacuum.

Figure 8 MCX connector and mating cable from Molex

6.2 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.

7 Data Interface – Antenna Deployment

The NanoCom ANT-6F VHF uses I^2C communication for its AR6 based release mechanism via the GSRB (GomSpace Release Bus). An API with the different functions used for deployment is found in the GSSB library provided by GomSpace.

8 Absolute Maximum Ratings

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

Symbol	Description	Min.	Max.	Unit
T	Temperature	-40	90	°C

9 Electrical Characteristics

ANT-6F VHF does not require any power.

10 Antenna Characteristics

Parameter	Condition	Min.	Typ.	Max.	Unit
RF impedance	Deployed	-	50	-	Ω
Input RF power		-	2	10	W
VSWR at matching point	Individual antenna		1.15	2	
VSWR at feed point			1.1	2	
Antenna system insertion loss	at 162 MHz	1	2	2.2	dB
Two Antenna ports isolation			14		dB
Frequency range		130	162	210	MHz
Temperature range		-40	-	85	°C

11 Physical Characteristics

Description	Value	Unit
Total mass of ANT-6F VHF, 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	320	mm

12 RF characteristics

12.1 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 polarization. The same applies for the bottom side. (See chapter 4)

12.2 Relative Gain and Phase

The antenna is designed with the goal of avoiding dead spots in the radiation pattern making it close to omnidirectional. There is loss due to the couplers, PCBs and RF cables, therefor the relative gain and phase shown below, are 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 in the following sequence with 90-degree phase shift: channel 2, channel 1, channel 3 and channel 4 as illustrated in the block diagram in chapter 3.2. Each coupler contributes maximum 7° phase error.

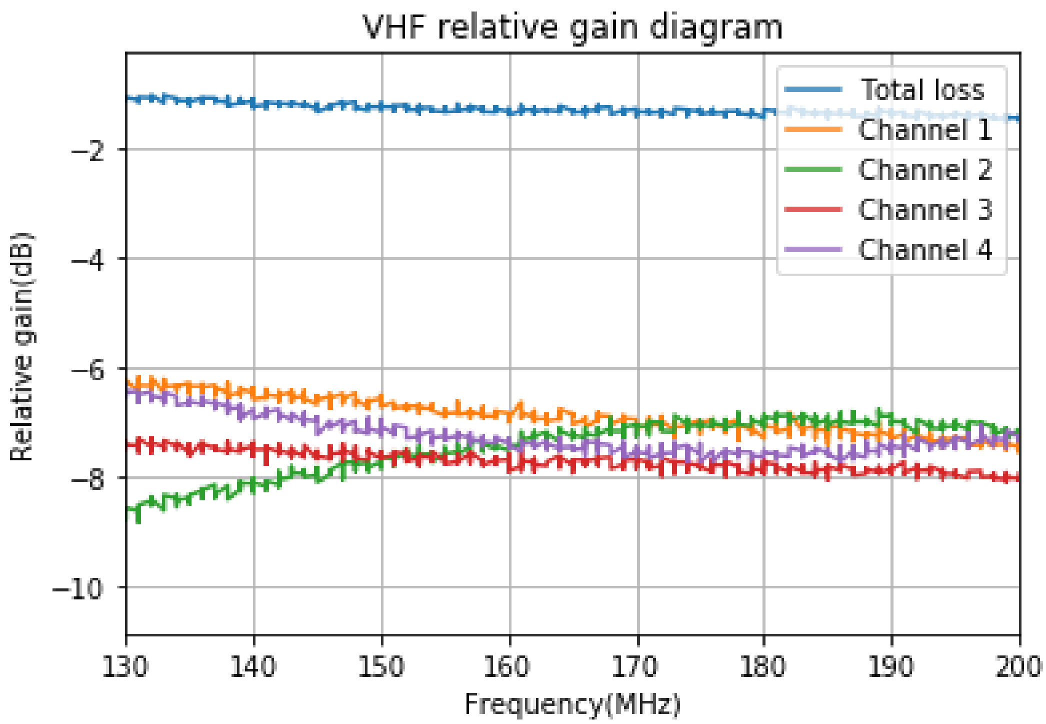


Figure 9 Signal has been sent at Input 1 and each color corresponds to the measured signal at different channels / U.FL antenna connectors. This is the measured gain due to the PCBs and coax cables.

From the figure above, we can conclude that the relative gain is within -6 dB and -9 dB for frequency range of 130-200 MHz. As expected from the couplers functionality, the gain is highest and similar in all the channels in the central frequency. For example, at 162 MHz, the relative gain is between -7.5 dB to -8 dB for each channel. The expected total loss is 3 dB for each coupler, and since the measured signal can pass through two couplers depending on the channel, the average expected loss is about 6 dB. Therefore, the measured values are within acceptable range.

The total system insertion loss due to the couplers, PCB and cables together on average is 1.2 dB as illustrated in Fig. 9.

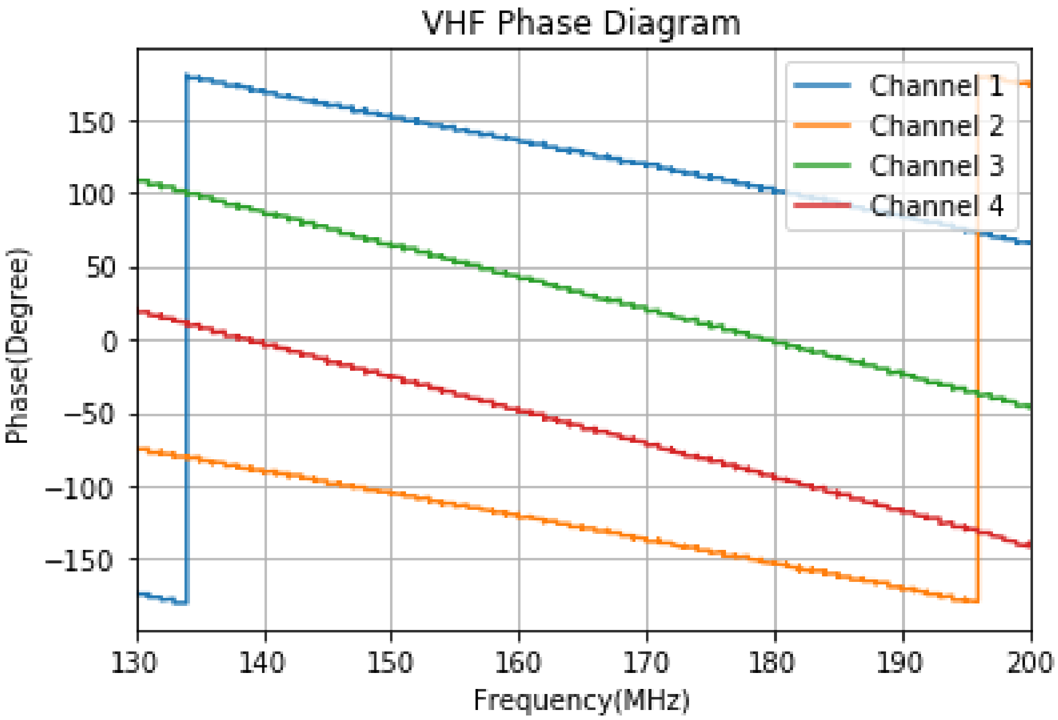


Figure 10 Signal has been sent at Input 1 and each color corresponds to the measured signal at different channels / U.FL antenna connectors. This is the absolute phase measured via network analyzer.

Since we are interested in the relative phase between the antennas and not the absolute phase to create a circular polarized signal, we need to look at the difference of phases between each channel for each desired frequency. (The absolute phase varies depending on the calibration and input signal, which regardless of that it will create a circular polarized signal as long as there is 90° phase difference between the antennas). From Figure 8 we can see that the difference between each consecutive channel (color) is about 90° for all the frequencies. Below is shown a different view of the relative phase between the channels at 162 MHz in polar coordinates. The reference channel (channel 2) has been set to zero to be compatible with Figure 1.

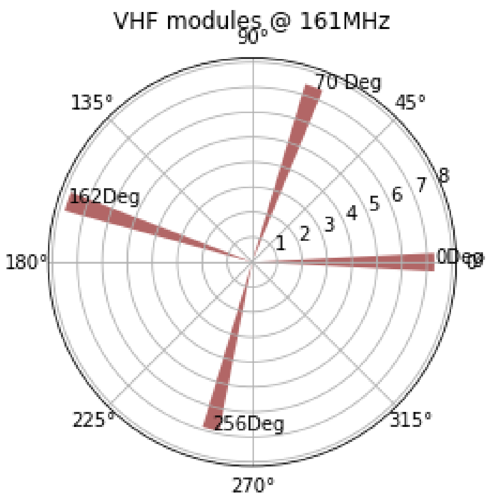


Figure 11 Phase illustration in degree in polar coordinate in terms of relative amplitude in -dB at 161 MHz. The reference channel is channel 2, which set to zero. Channel 1, 3, and 4 are represented clockwise, respectively.

12.3 Radiation Pattern of a 6U Satellite

The actual gain characteristics depend on the shape of the spacecraft and its deployable structures.

As an example, the GomSpace GOMX4 satellite is a uniform 6U CubeSat. The simulated gain is shown in Fig. 12 and Fig. 13.

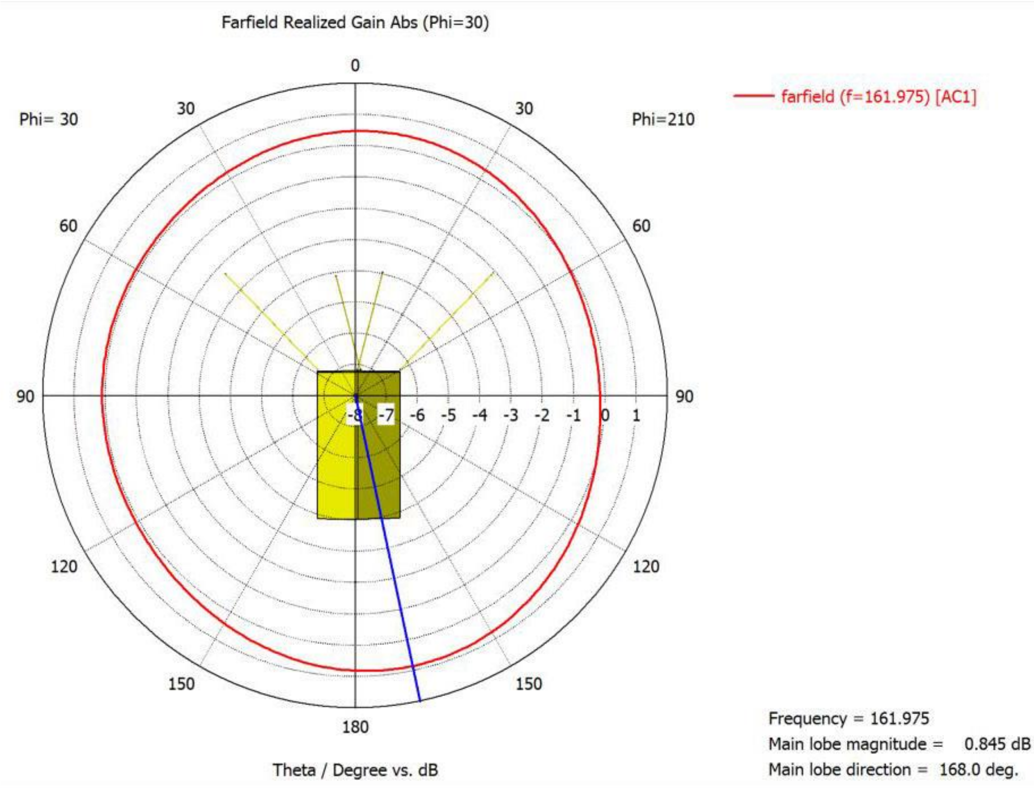


Figure 12 Farfield realized gain simulated by CST program. The illustration shown in polar coordinate looking 30° into the 3U side of the satellite, including the satellite.

The represented simulated radiation pattern is the Farfield realized gain both in polar and 3D view including the loss due to mismatching to 50 Ω, simulated at 30° which is the angle of the satellite toward nadir in GOMX4 mission.

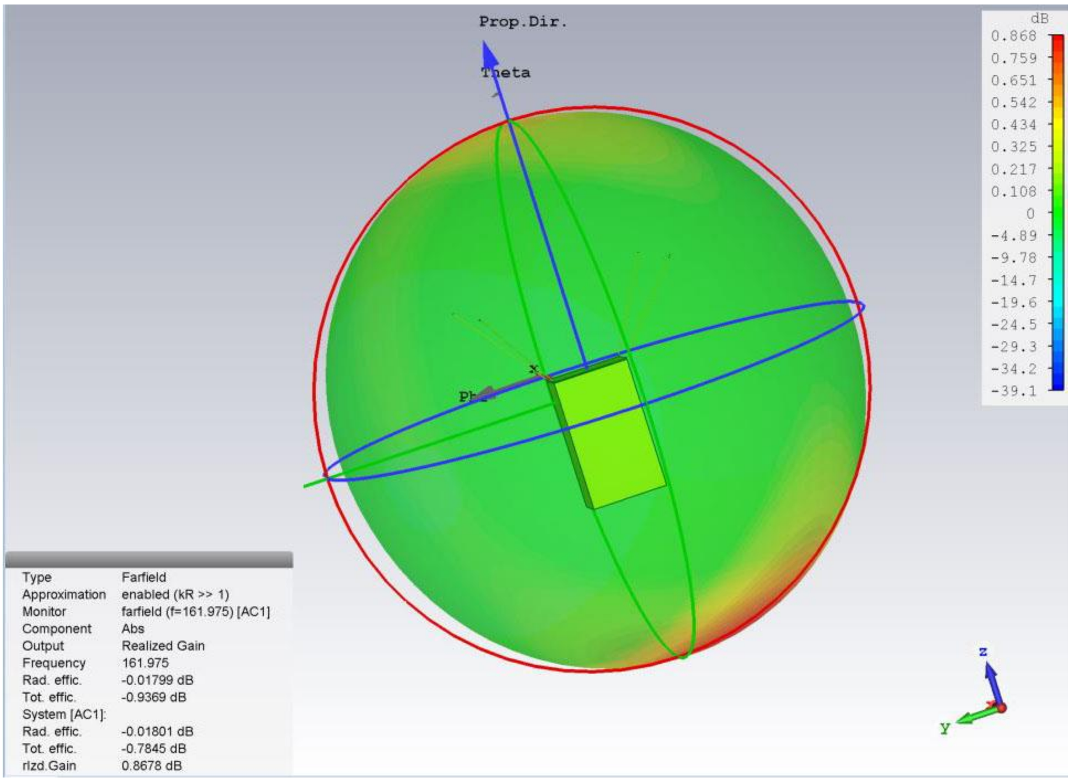


Figure 13 Farfield realized gain simulated by CST program. The illustration shown in 3D view, including the satellite orientation.

As can be seen in the above figures, the highest gain (0.86 dB) is along the long Z-axis of the CubeSat, opposite direction of the antenna location, with lower gains along the X- and Y-axes.
The simulated results represented above, used the relative measured phase from PCBs represented in Fig. 11. The deviation of phases from ideal 90° phase difference had negligible effect on the output gain (less than 0.3 dB). Therefore, the acceptable relative phase for each channel is defined in the following table:

Channel no.	Min. acceptable phase (degree)	Ideal phase (degree)	Max. acceptable phase (degree)
1	70	90	110
2	-20	0	20
3	160	180	200
4	250	270	290

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 at a reasonable cost.

12.4 Impedance

Apart from the PCBs and RF feeding points, which their impedance designed to be matched to 50 Ω, the antenna elements are also matched to 50 Ω via T-network individually. The impedance for one of the antenna elements illustrated in a smith chart in Fig. 14 and the return loss illustrated in Fig. 15 in dB.

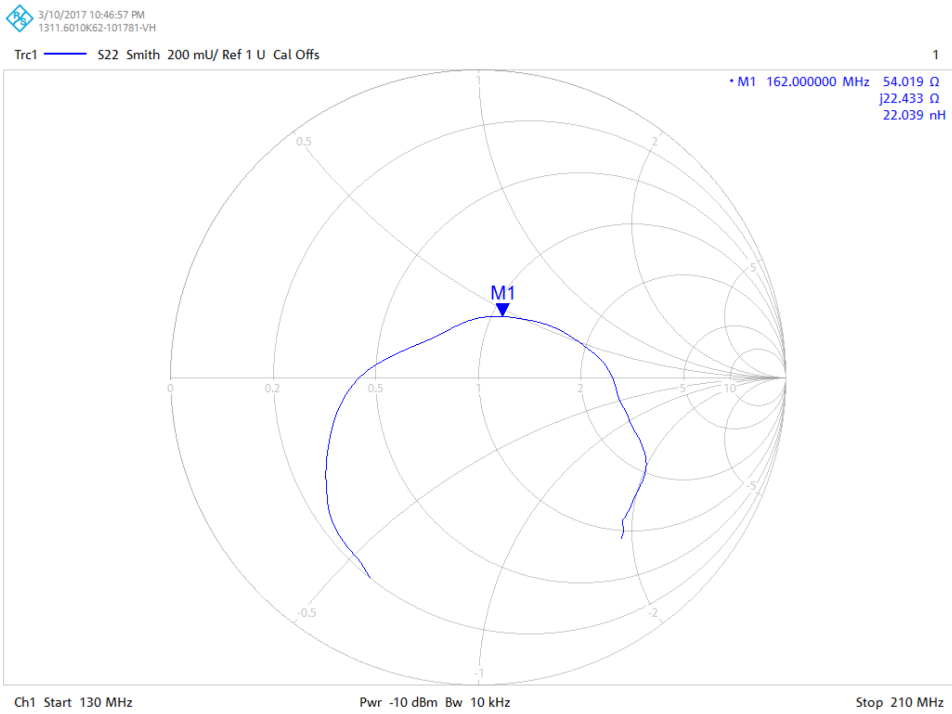
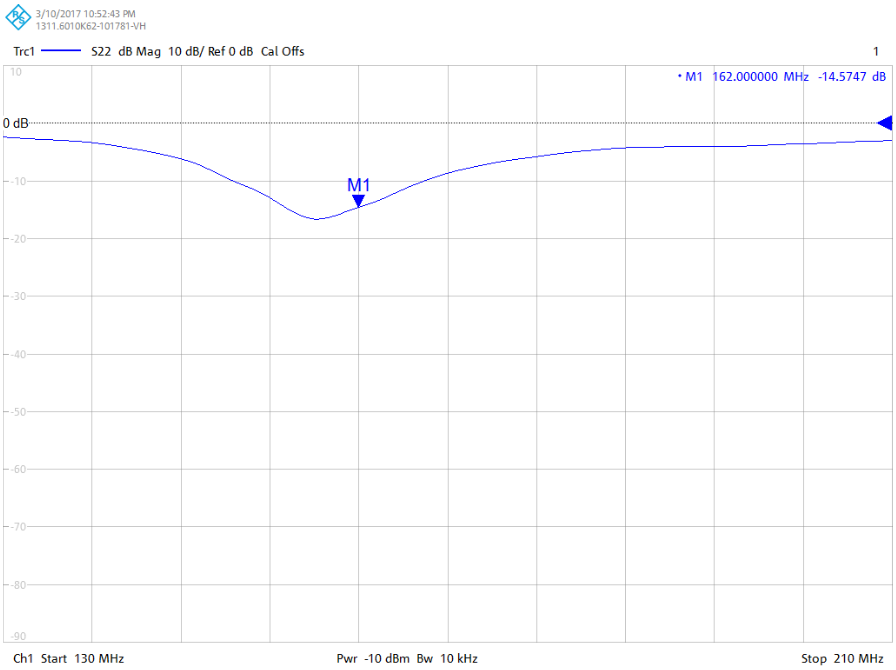


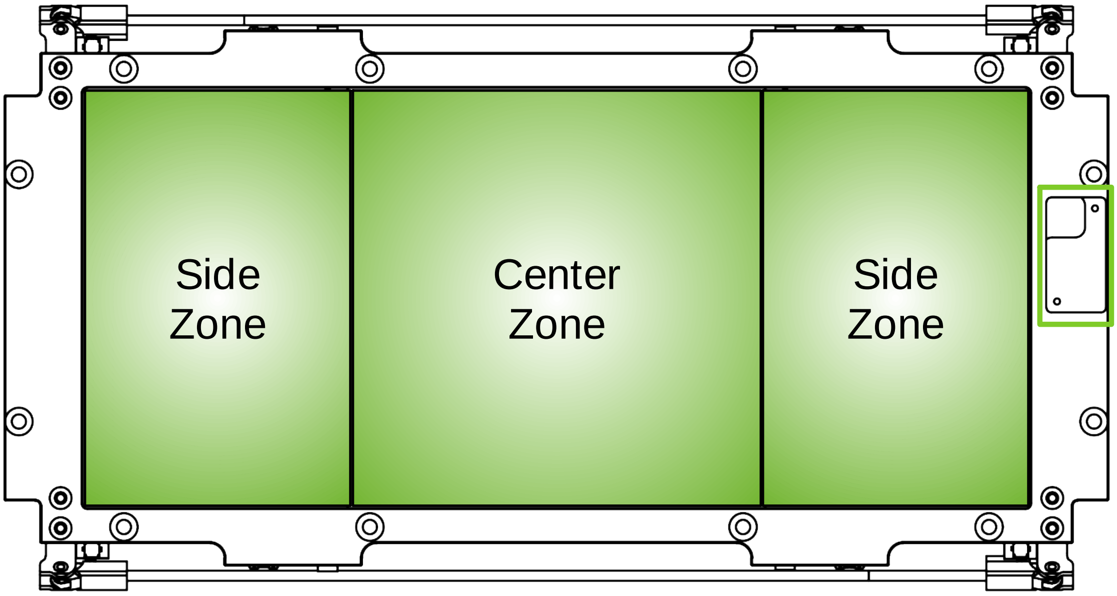
Figure 14 Smith illustration of impedance measurement at one of the antenna ports, with antenna rods and with matching components mounted on the other ports. Also, the full system installed on a 6U structure for more realistic results.



Figur 15 Return loss 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.

13 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 sales person.

Right most 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.

14 Frequency Variant

The ANT-6F VHF comes in two variants.

Variant	Description
NanoCom ANT-6F-H	VHF 162±2 MHz
NanoCom ANT-6F-L	VHF 160±5 MHz

15 Environmental Test

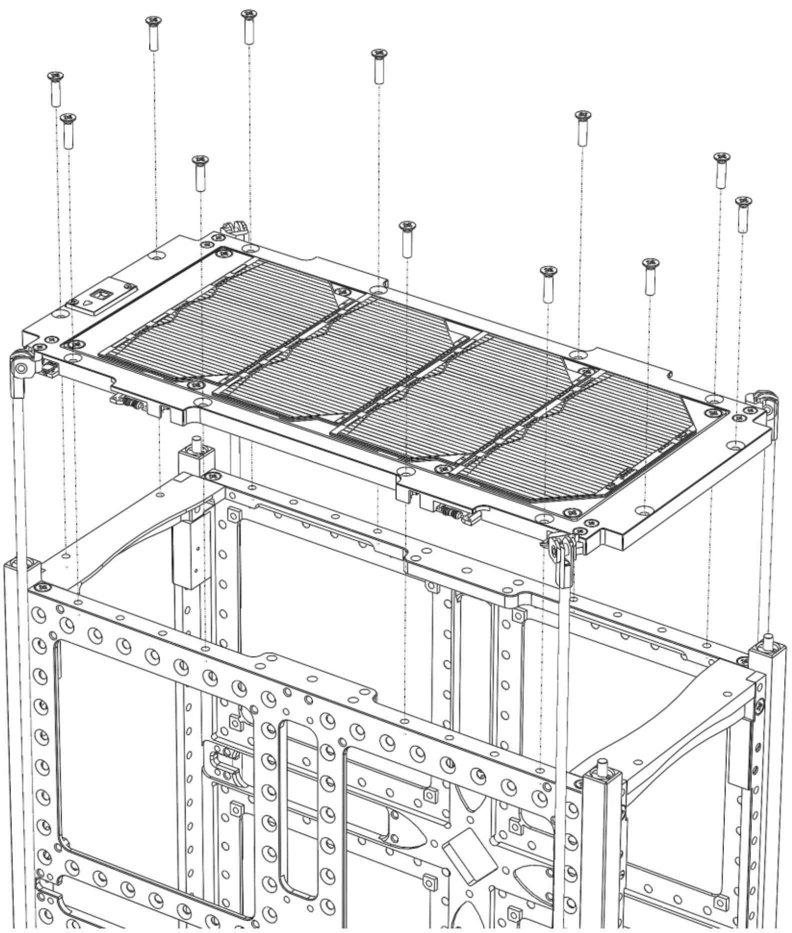
To simulate the harsh conditions of launch and space, the ANT-6F has been exposed to a number of environment tests. Contact GomSpace for further information.

16 Integration

The holes for mounting modules on top the mounting bracket are M2.5.

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 side and M2.5 X10 screws on the long side.



17 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. The ANT-6F VHF does not contain power amplifiers or low noise amplifiers. Therefor it cannot be used together with transceivers without build-in amplifiers such as NanoCom TR-600

17.1 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 all four antennas are used. The optimal solution would be to continuously monitor and switch between polarizations of the ground station antenna, but this is sometimes not feasible to have a ground station operator present to do that.

17.2 Redundant radios

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

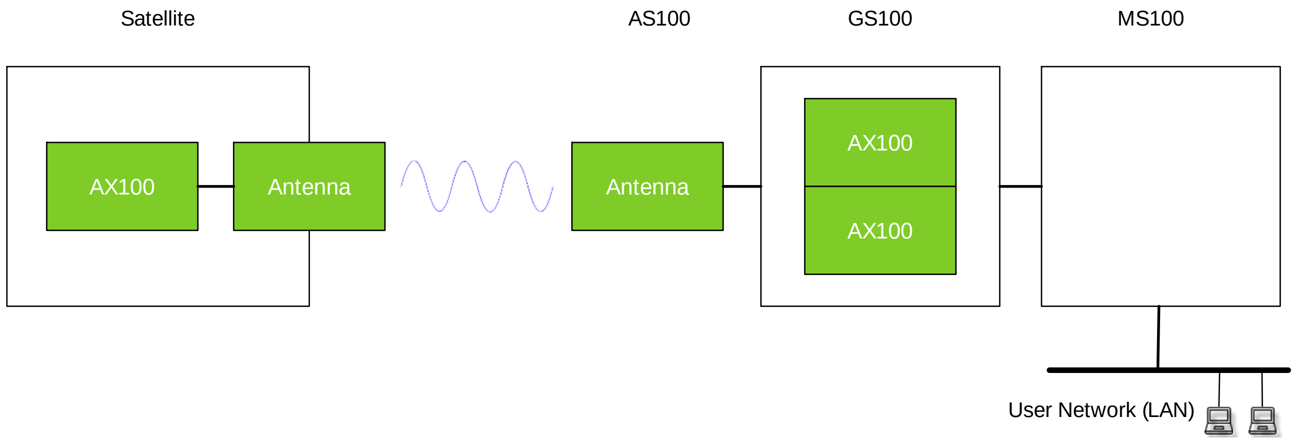
By connecting two AX100 for example to ANT-6F VHF, cold redundant AX100 radios would be controlled by the OBC or another system by simply switching the power to the AX100's off and on. In cold redundant mode, only one out of the two radios can be switched on at a time, and they share exactly the same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

Another possibility would be to combine two AX100's as VHF/UHF. In this scenario, one AX100 needs to be connected to ANT-6F UHF on one side of the satellite and the other AX100 needs to be connected to ANT-6F(VHF) on the other end of the satellite. 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.

17.3 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.

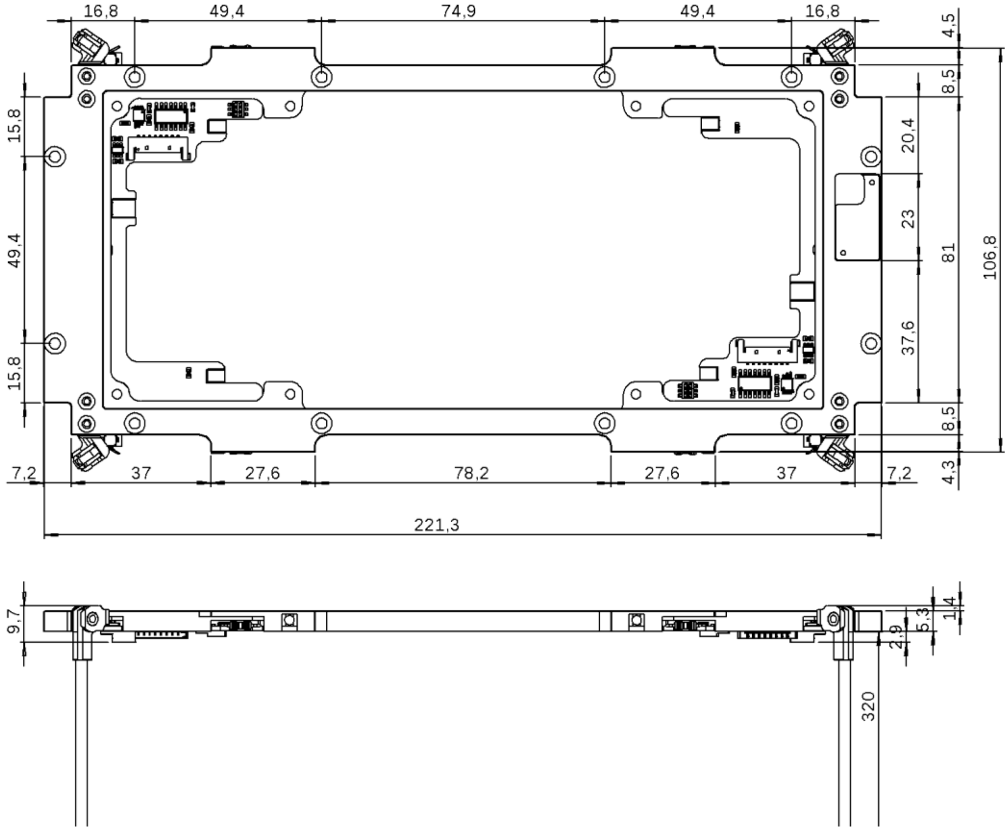
The GS100 is a 19" rack mounted unit that contains two NanoCom AX100 compatible radio units and hence delivers the optimal solution. The unit ensures that no matter which polarization is optimal, one of the radios will be listening. Also, it improves the G/T of the ground station, because the insertion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



See the individual datasheets for further information.

18 Mechanical Drawing

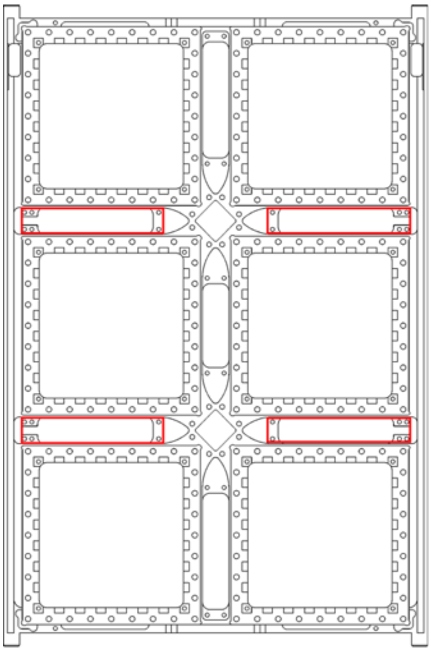
All dimensions in mm.

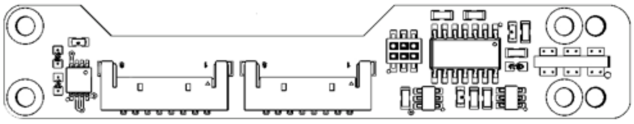


19 Overview – AR6

The primary function of the GomSpace NanoUtil AR6 (AR6) is to provide a release mechanism for VHF antennas in GomSpaces 6U structure.

The AR6 is placed on the 6U side of a structure. On each side, there are four slots allocated for the AR6'es. All can be set in series through the connectors on the PCB.





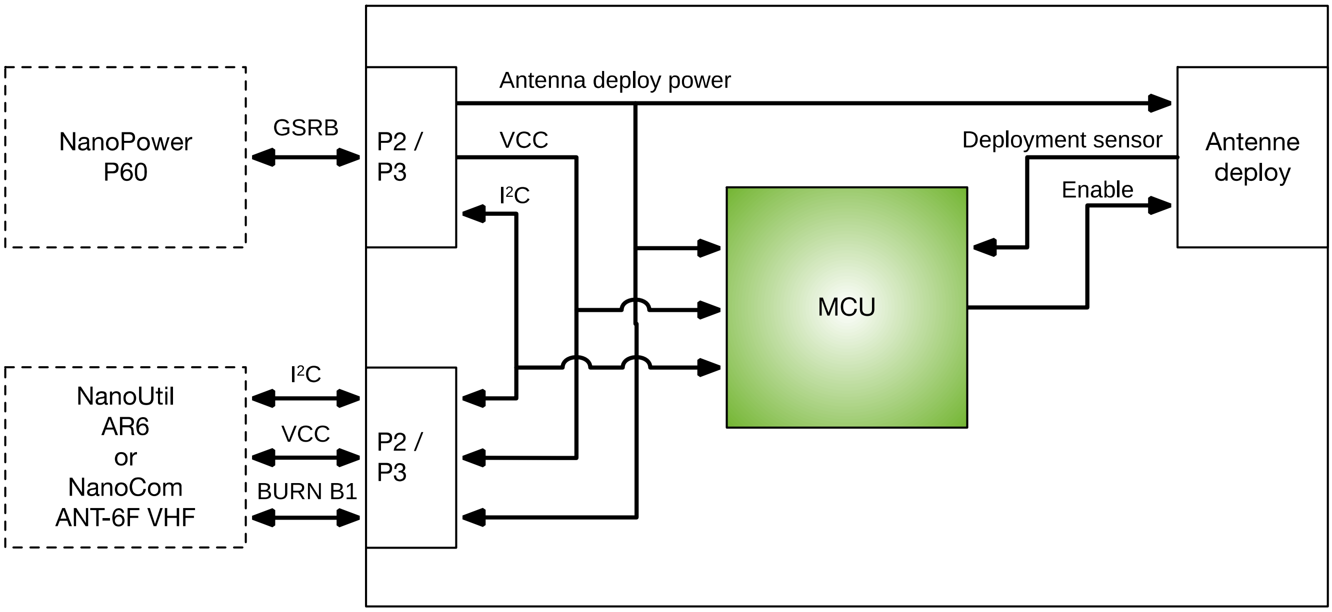
The front of the PCB contains all the electronics and connectors. The bottoms only contain the countersunk holes for mounting. Except for the antenna release, the whole PCB will be covered from the outside by solar panels.

19.1 Highlighted Features

- Antenna release with deployment sensor feedback
- Connector to the NanoPower P60
- Connector to other NanoUtil AR6's
- Operational temperature: -40 °C to +85 °C
- PCB material: Glass/polyimide
- IPC-A-610 Class 3 assembly

19.2 Block Diagram

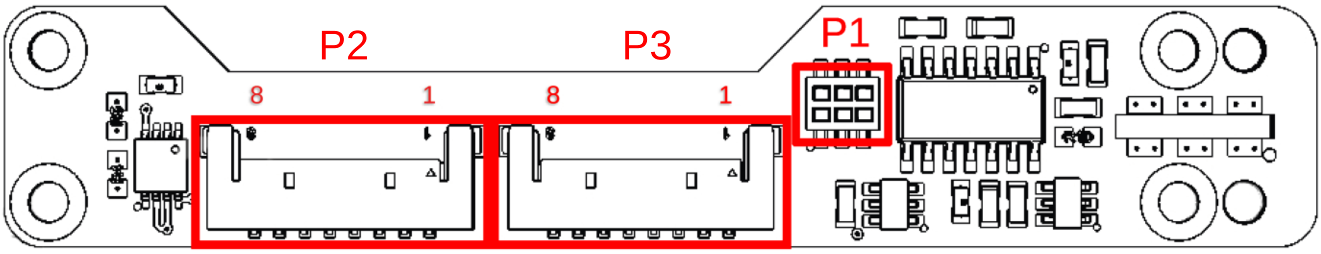
The AR6 carries the power supply for the release mechanism in form of GND and 5 V. SDA and SCL signals are used for communication. The maximum I²C bus speed is 100 kHz and this applies to all communication on the bus.



GSRB = GomSpace Release Bus

20 Hardware Layout

20.1 Connector Location Top



20.1.1 P1 – GomSpace Debug

Internal use.

20.1.2 P2 – GSRB/Serial AR6 Connector

Molex PicoLock 1.5 mm pitch 504050-0891

Connects to one of the following: NanoPower P60 Dock (connector P8 and P9), another AR6 or NanoCom ANT6F-VHF (Connector J2 or J3).

Pin	Description
1	BURN_GND
2	BURN_GND
3	BURN B1
4	BURN_B1
5	Data GND
6	VCC
7	SCL
8	SDA

20.1.3 P3 – GSRB/Serial AR6 Connector

Molex PicoLock 1.5 mm pitch 504050-0891

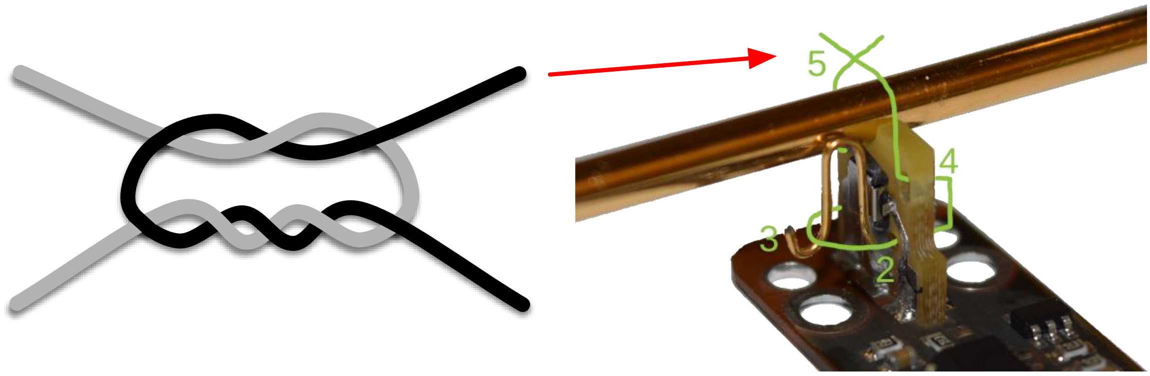
Connects to one of the followings: NanoPower P60 Dock (connector P8 and P9), another AR6 or NanoCom ANT6F-VHF (Connector J2 or J3).

Pin	Description
1	SDA
2	SCL
3	VCC
4	Data GND
5	BURN_B1
6	BURN_B1
7	BURN_GND
8	BURN_GND

21 Antenna Stowing Procedure

Procedure to tie up the antenna to the release mechanism:

1. Use 40 cm burn wire.
2. Insert both ends of wire through the inner holes of the release PCB from the side with the spring.
3. Place loop of wire around hook on spring.
4. Pull both ends over the burn resistors and through the outer two holes.
5. Lightly press and hold the spring while tying the ends around antenna using two surgeon’s knots, one on top of the other.
6. Use a knife or scissor to remove the remaining wire after the knot



22 Absolute Maximum Ratings

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the AR6. Exposure to absolute maximum rating conditions for extended periods may affect the reliability.

Symbol	Description	Min.	Max.	Unit
VCC	Supply voltage		3.4	V
BURN B1	Antenna deploy power (Burn resistor voltage)		5	V
Burn T	Burn time for burn wire		3.5	s
T	Operating Temperature	-40	85	°C

23 Electrical Characteristics

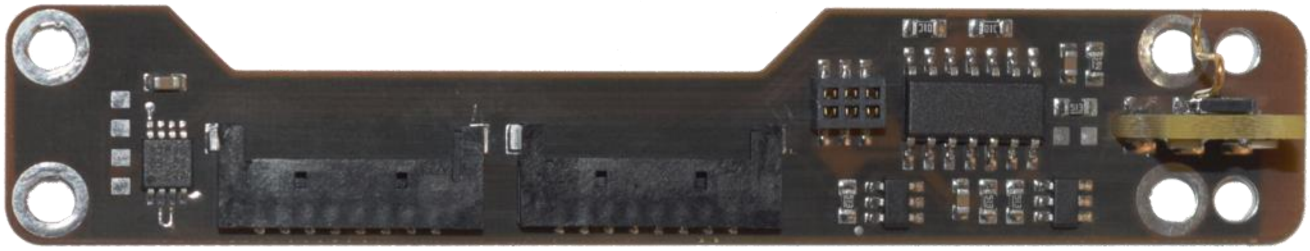
Symbol	Description	Min.	Typ.	Max.	Unit
VCC	Supply voltage		3.3		V
I	Supply current		50		mA
BURN B1	Antenna deploy power (Burn resistor voltage)		5		V
Burn T	Burn time for burn wire	1	1	3.5	s

24 Physical Characteristics

Description	Value	Unit
Mass	3	g
Size	78 x 14 x 11.5	mm

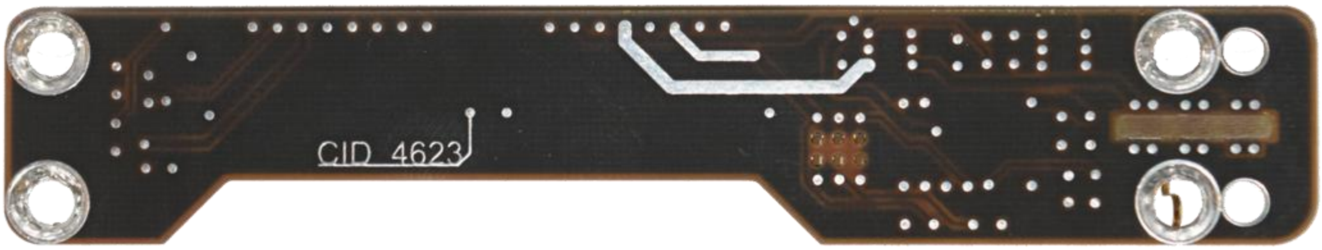
25 Physical Layout

Top



Components from left to right. I²C isolator, 2x Molex connectors, MCU connector, the MCU and the antenna release system.

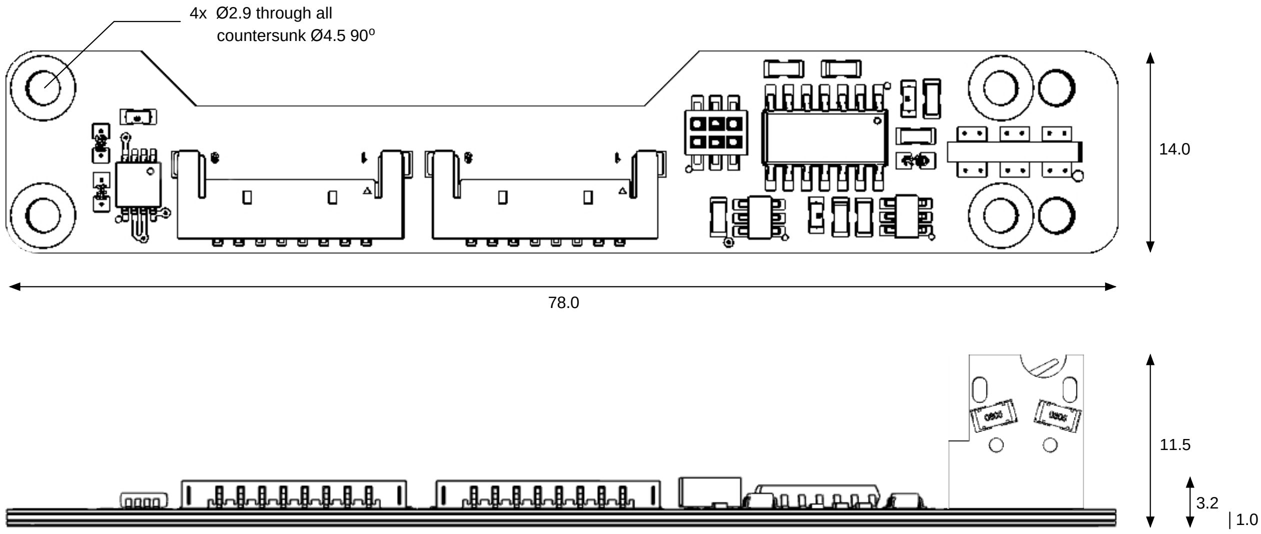
Bottom



Contains no components. Four countersunk holes for M2 screws.

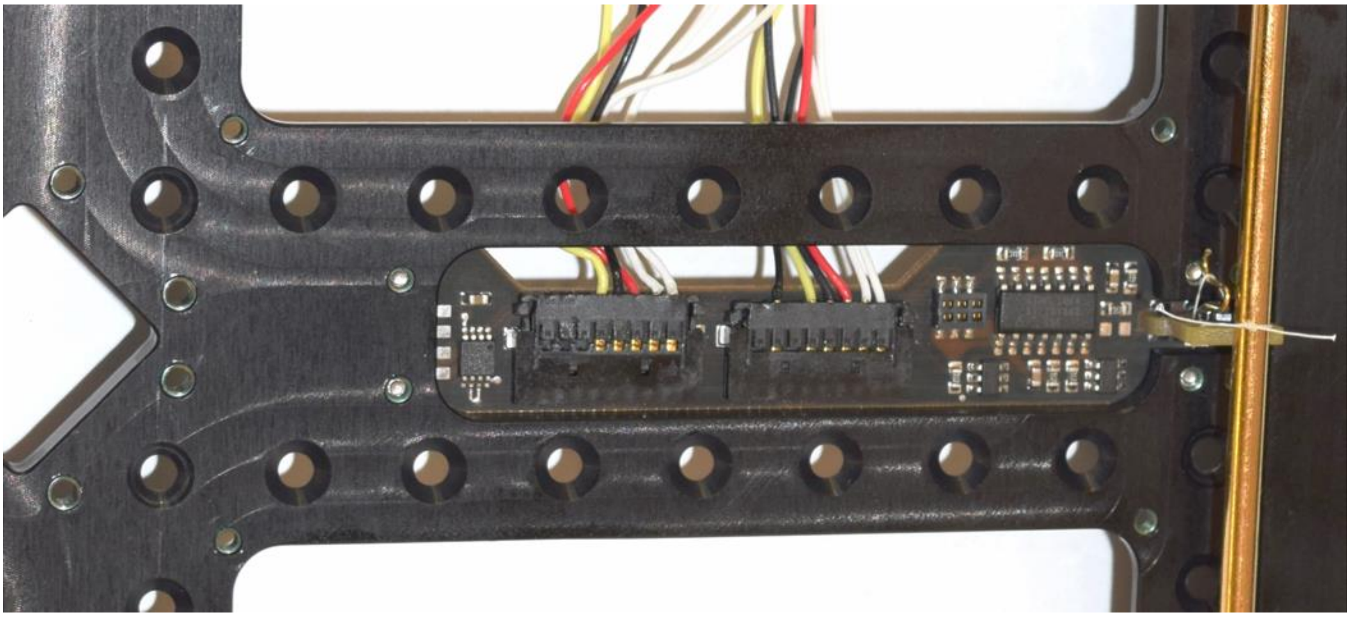
26 Mechanical Drawing

All dimensions in mm.

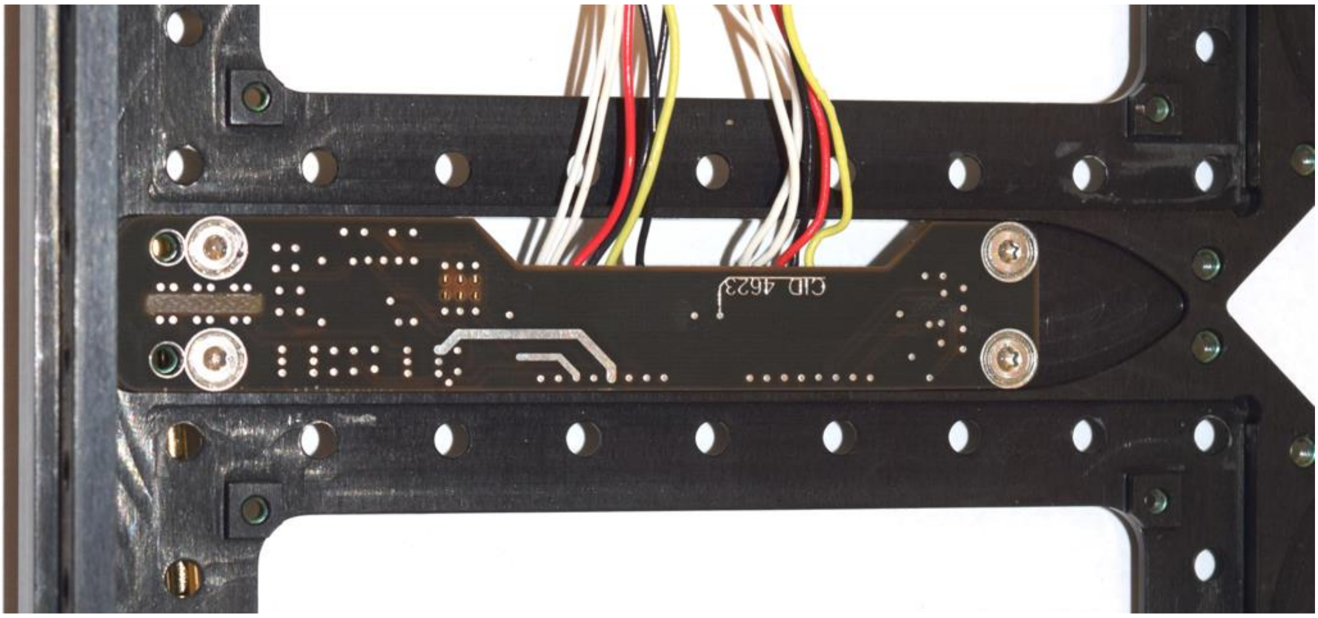


27 AR6 in GomSpace 6U Structure

The pictures below show the NanoUtil AR6 mounted in the GomSpace 6U structure.



Top side with an antenna tied to the release mechanism and harnesses connected to show how the wires exit.



Bottom side shows the mounting with the countersunk screw holes

Solar panels will be mounted on top the structure, so only the release tab peaks out.

29 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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