

Datasheet for the X-band Antenna

Version 0.1

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Revision History

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0.1	04 Jul 2024	Initial release

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1 Overview

The passive array microstrip antenna operates in the X-band frequency range, making it ideal for satellite communication applications requiring high throughput. Designed for small satellite applications, this antenna features a compact, lightweight construction ensuring efficient space utilization and ease of integration. The antenna leverages advanced microstrip technology and provides excellent gain and directivity, enhancing signal strength and quality for satellite communication systems.

Features

- Operates in the 8050-8400 MHz X-band allocation for Earth science satellites
- Flat passive microstrip array
- Designed to be integrated with INRASE high-throughput X-band transmitter (PRDC)
- Gain of 18.5 dB is 3 dB higher than typical competing antennas targeted for 1U formfactor, that provides corresponding link budget improvement
- Test cap (test hat) is available for the satellite integration testing

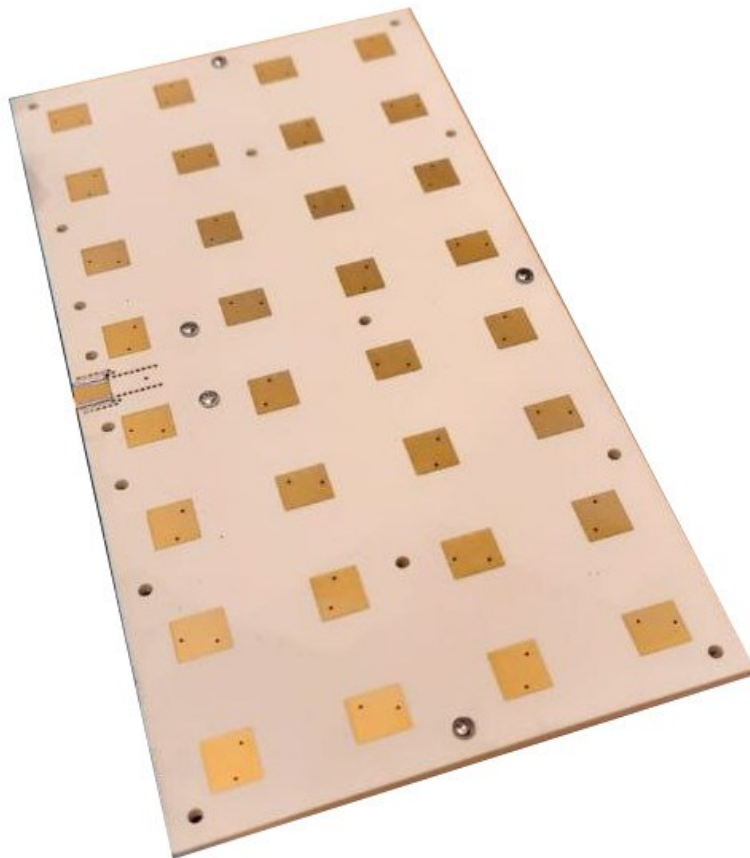


Figure 1 X-band Antenna

2 Specifications

2.1 Key Specifications

Table 1. Key Specifications

Parameter	Min	Typ	Max	Unit
RF specifications				
Frequency band	8050	8220	8400	MHz
Gain at central frequency in $\pm 1^\circ$ sector	18.0			dB
Gain flatness in full band			± 0.6	dB
Output impedance		50		Ω
VSWR in full band			1.6	
Polarization	Circular, right-hand			
Axial ratio at 8220 MHz in $\pm 1^\circ$ sector			3	dB
Axial ratio in full band in $\pm 1^\circ$ sector			4.4	dB
Radiation pattern width in XY plane at -3 dB ¹		± 4.5		deg
Radiation pattern width in ZY plane at -3 dB ¹		± 9.5		deg
RF power at the input connector			10	W
Environmental specifications				
Operating temperature	-50		+100	$^\circ\text{C}$
Storage temperature	-50		+100	$^\circ\text{C}$
Vacuum	10^{-12}		10^{-5}	torr
Mechanical specifications				
Dimensions (w/o connector)	100x200x3			mm
Mass			130	g

Note 1. See outline drawing (sec 5.1) for the axes directions.

2.2 Environmental Specifications

Sinusoidal sweep vibration operational levels for each device axis are specified in Table 2. The antenna shall not have resonances in the 1 – 100 Hz band.

Table 2. Sinusoidal Sweep Vibration Specifications

Frequency subbands, Hz	1-2	2-5	5-10	10-15	15-20	20-100
Amplitude, $g = 9.81 \text{ m} / \text{s}^2$	0.3-0.5	1.0	1.0-1.2	1.2-4.0	4.0-10.0	10.0
<i>Note:</i> Test duration 600 s each axis.						

Random vibration operational levels for each device axis are specified in Table 3.

Table 3. Random Vibration Specifications

Frequency subbands, Hz	20-40	40 - 100	100 - 300	300 - 600	600 - 1200	1200 - 2500
Acceleration spectral density, g^2 / Hz	0.04-0.50	0.50	0.50	0.50-0.20	0.20-0.06	0.06-0.02
<i>Note:</i> Test duration 600 s each axis.						

Shock operational levels for each device axis are specified in Table 4.

Table 4. Shock Specifications

Frequency subbands, Гц	30-50	50-150	150-200	200-500	500-1000	1000-2000	2000-5000
Shock response spectrum, g	15-40	40-160	160-200	200-1000	1000	1000	1000
Shocks per each axis	10 (5 in each direction)						
Total number of shocks	30						

Total Ionizing Dose tolerance is 10 Mrad. The device is not susceptible to single events.

3 Principles of Operation

The X-band Antenna is a passive microstrip antenna array. Its operation is based on the principles of electromagnetic wave propagation and resonance. The array consists of a matrix of microstrip patch elements, each acting as a radiating element, printed on a dielectric substrate. These elements are fed by a network that distributes the input signal uniformly across the array, ensuring coherent radiation. The patches resonate at specific frequencies in the X-band, converting the guided electromagnetic waves into free-space radiation efficiently. The array configuration allows for constructive interference of the radiated waves, to enhance the overall gain and directivity. The passive nature of the antenna means it does not require active components, relying solely on the spatial arrangement and feeding network to achieve the desired radiation pattern and performance.

The antenna is made from woven glass reinforced hydrocarbon/ceramics dielectric material, that complies with NASA outgassing requirements. Front side (“A” in Figure 9) features microstrip patch radiating elements, with immersion gold plating. The antenna backside (“B” in Figure 9) shall be mounted on the flat conducting surface of the satellite.

The SMA connector ensures a reliable interface between the feeder cable and the antenna. Larger diameter and more rigid coaxial cables can be used.

4 Typical Performance Graphs

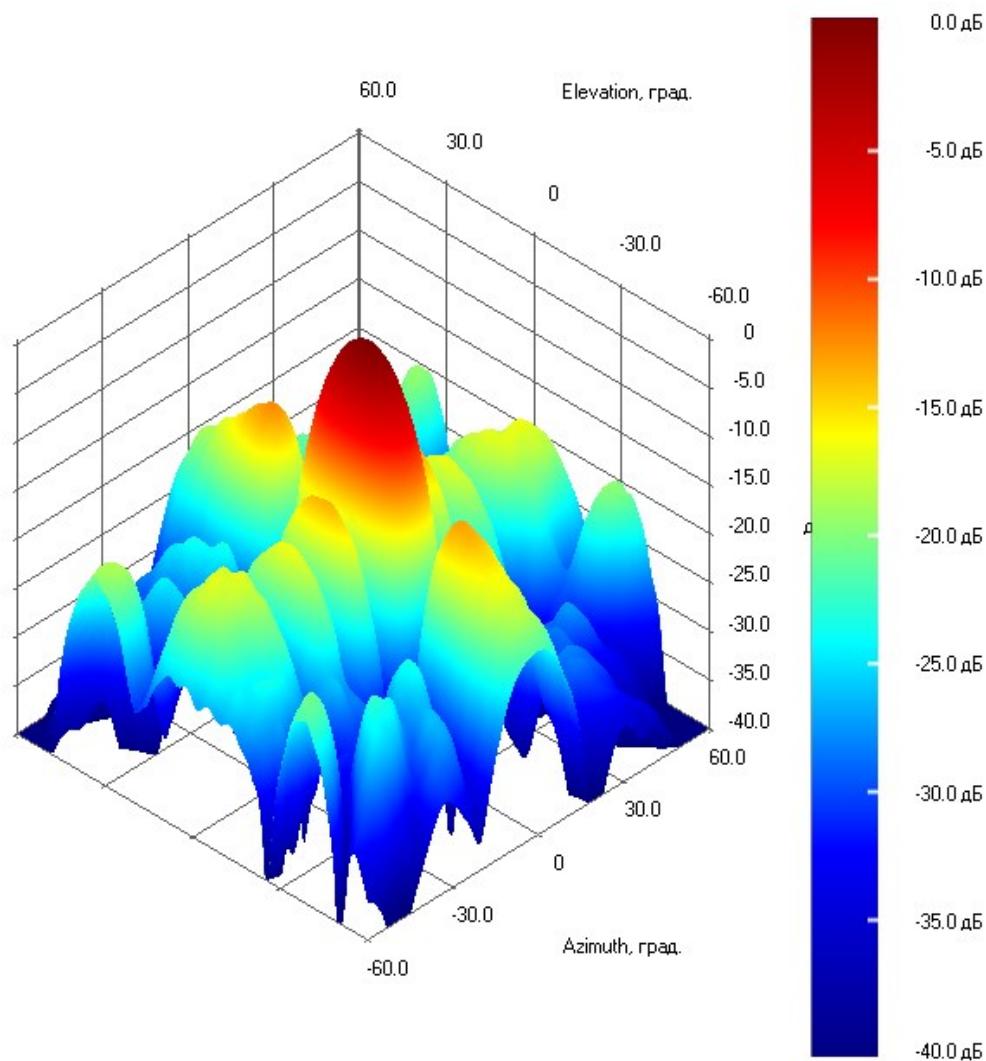


Figure 2 3D Radiation Pattern at 8220 MHz

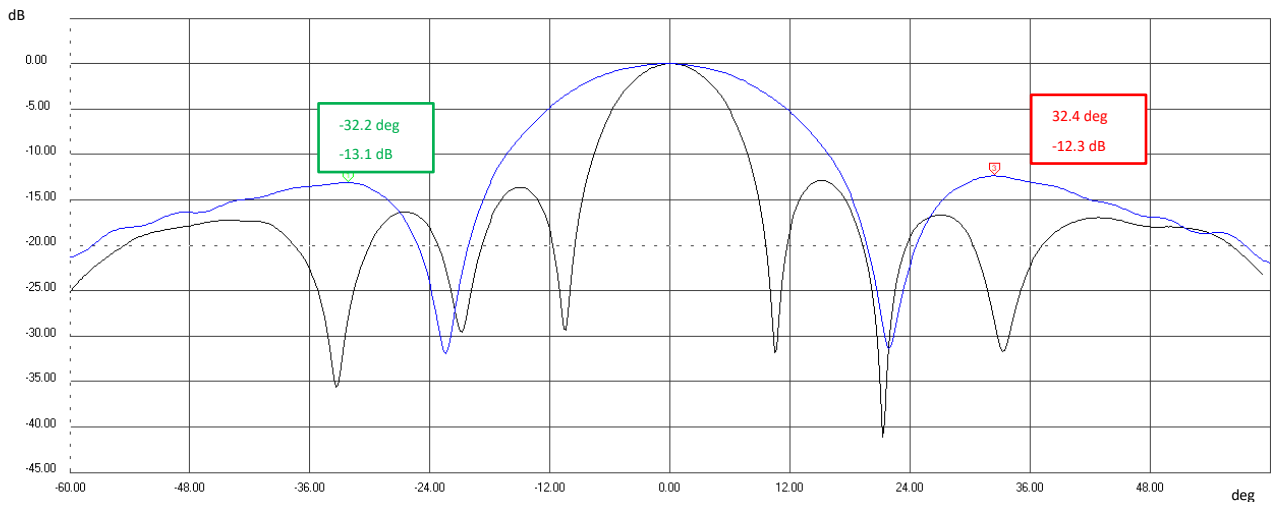


Figure 3 Azimuth (Black) and Elevation (Blue) Radiation Pattern Sections (8220 MHz)

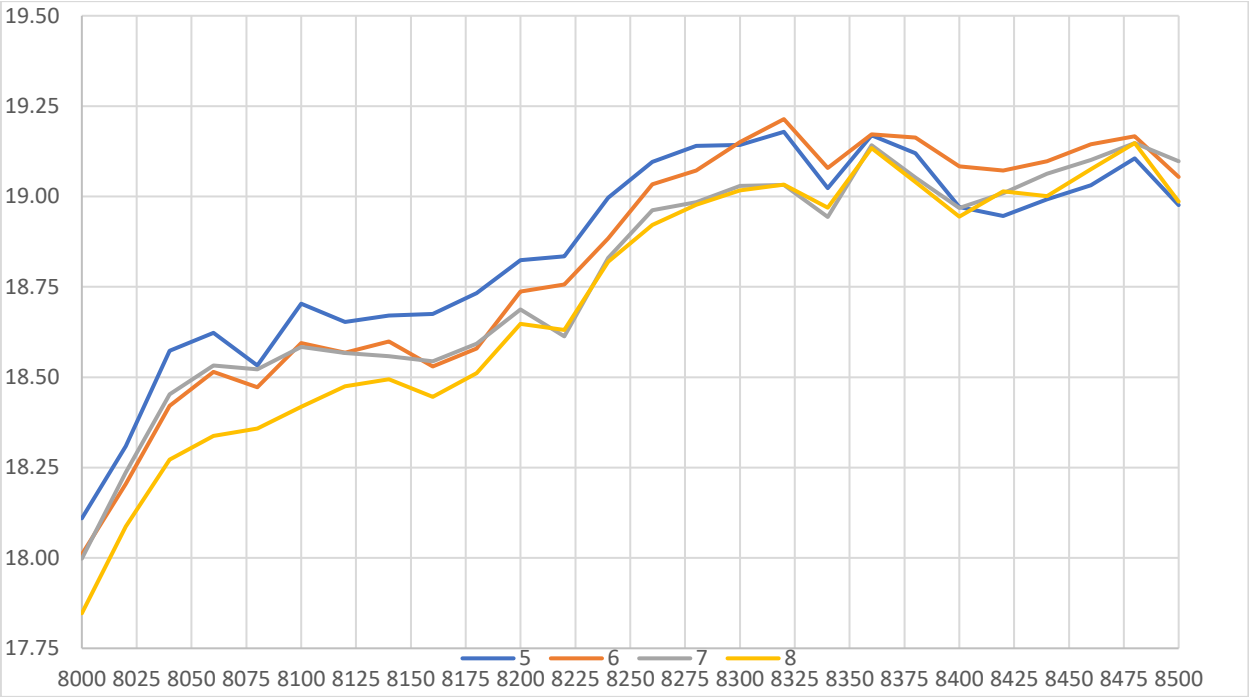


Figure 4 Broadside Gain (dB) vs Frequency (MHz) (Devices Ser.# 5 - 8)

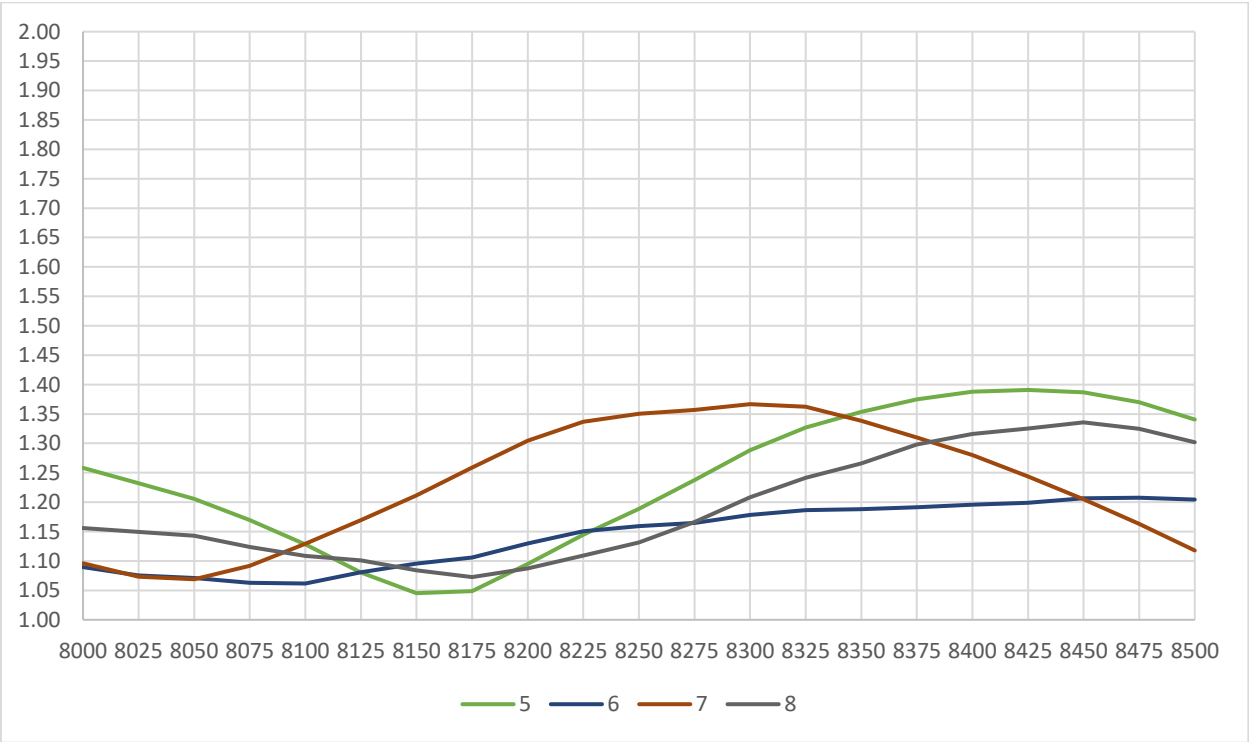


Figure 5 VSWR vs Frequency (MHz) (Devices Ser.# 5 - 8)

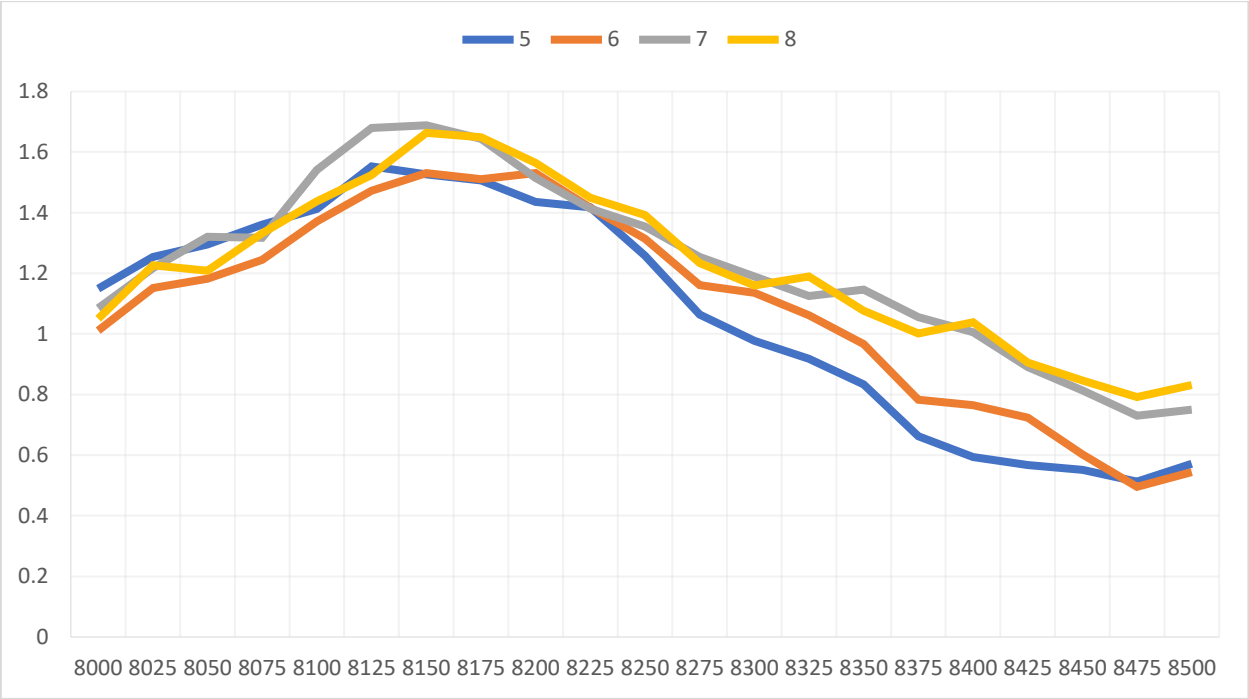


Figure 6 Axial Ratio (dB) vs Frequency (MHz) (Devices Ser.# 5 - 8)

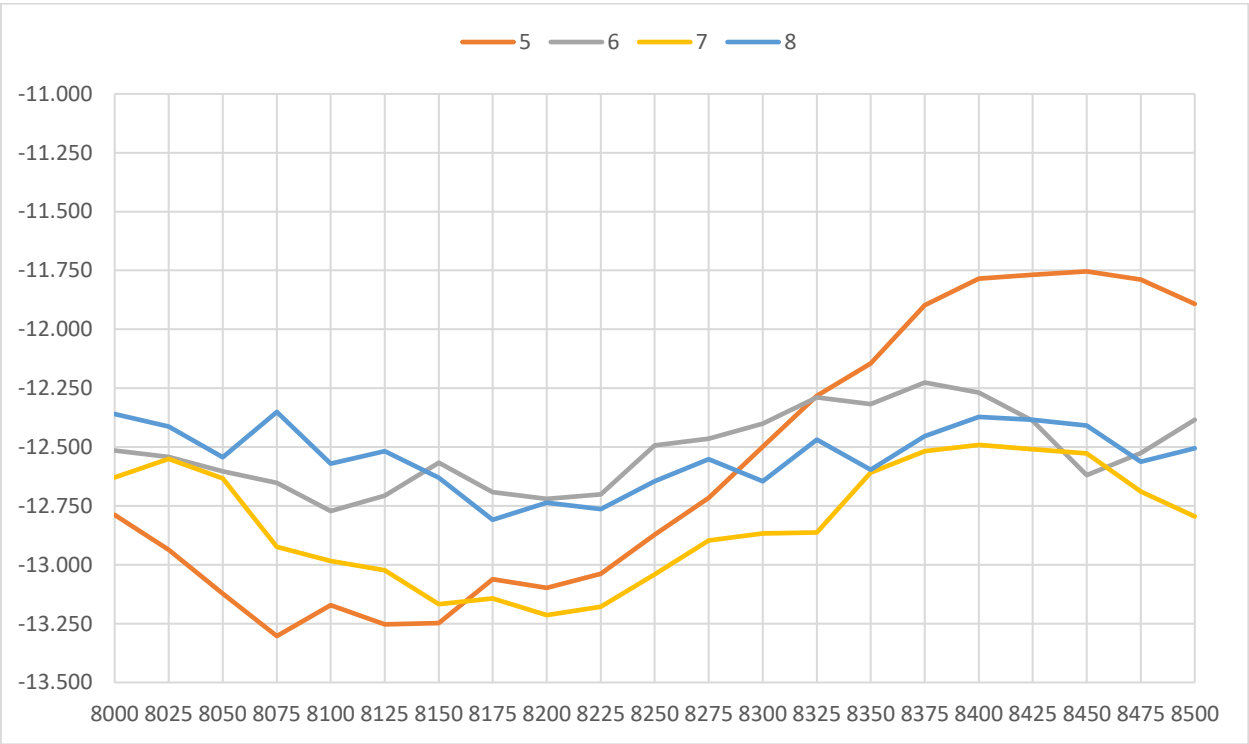


Figure 7 Side Lobe Peak Level in Azimuth (dB) vs Frequency (MHz) (Devices Ser.# 5 - 8)

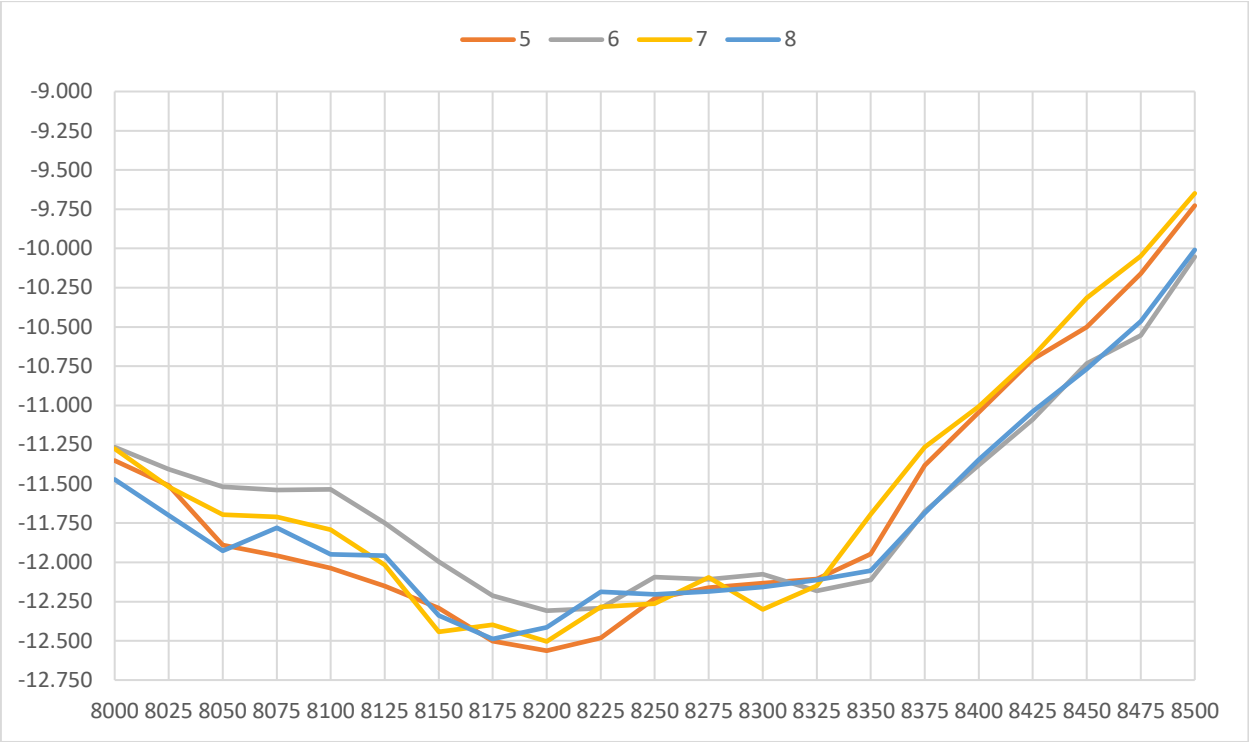


Figure 8 Side Lobe Peak Level in Elevation (dB) vs Frequency (MHz) (Devices Ser.# 5 - 8)

5 Mechanical Characteristics

5.1 Transmitter Envelope and Mounting

The Antenna envelope and mounting provisions shall be as shown in Figure 9. The transmitter can be mounted with M2,5 (2.5 mm diam.) dielectric bolts.

5.2 Connector Position

The connector location is identified in Figure 9. The connector type is SMA receptacle.

5.3 Mass and Center of Gravity

The mass of the Antenna will not exceed 130 g. The center of gravity of the unit is as shown in Figure 9.

5.4 Mounting Interface

Mounting surface is marked “B” in Figure 9. It has continuous copper cover with immersion gold plating.

The satellite surface where the antenna will be mounted shall have flatness of .15 mm with surface finish of 1.0 μm .

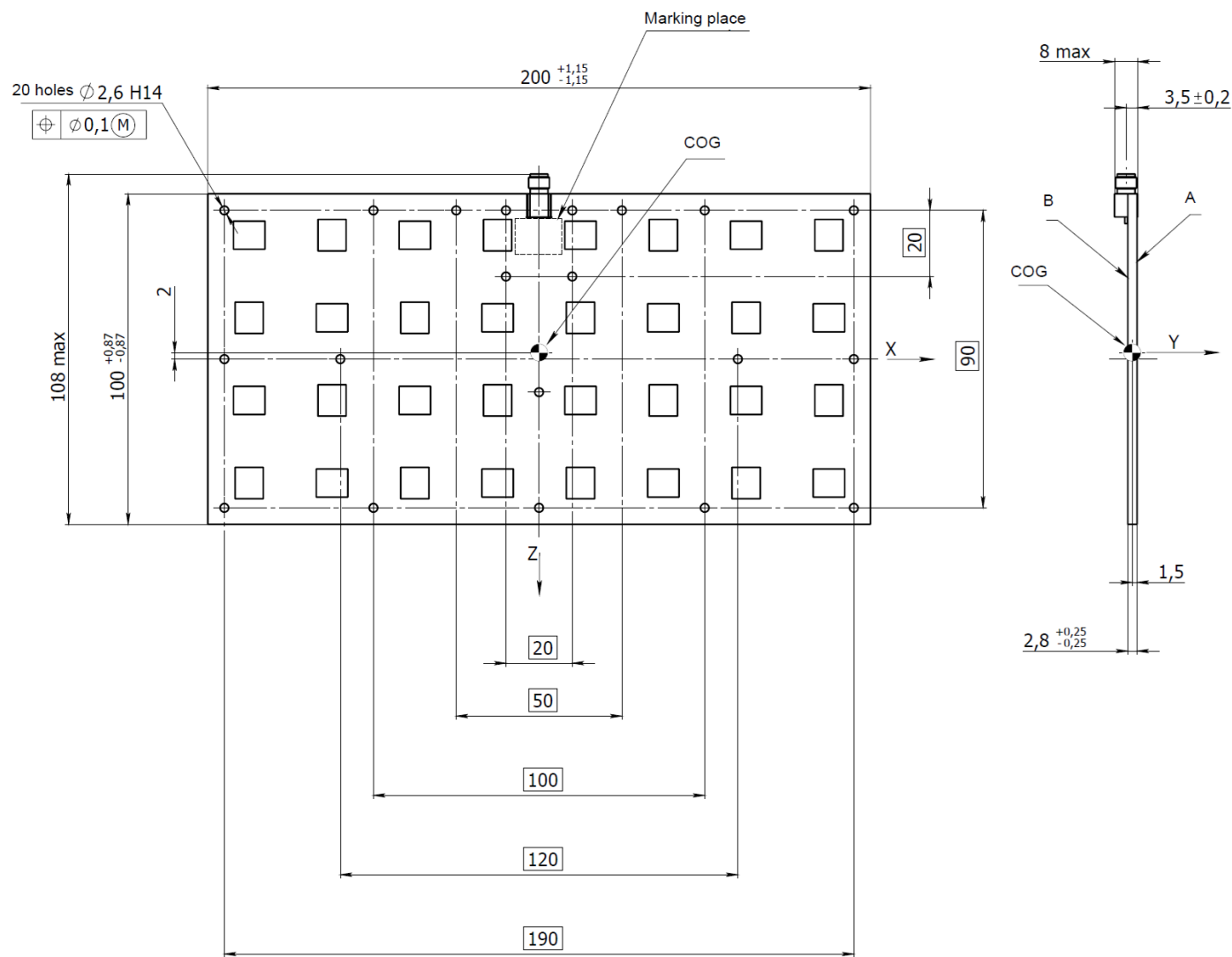


Figure 9. Antenna Outline Drawing

6 Testing Outline

Testing procedures are listed in Table 5.

Table 5. Test Procedures List and Requirements

Item	Test	Qualification Tests	Acceptance Tests	Notes
1	Production documentation compliance, dimensions and weight	+	+	
2	Electrical parameters at normal temperature	+	+	1
3	Temperature range			
3.1	High operating temperature	+105 °C	+103 °C	2
3.2	Low operating temperature	-55 °C	-53 °C	2
4	Vibration	Per Table 2 Per Table 3	Per Table 6 (sinusoidal sweep)	3,4
5	Shock	Per Table 4	–	3

Notes

- Electrical parameters test includes
 - S-parameters measurements
 - Radiation pattern measurement in full band
 - Gain and axial ratio measurements in full band
- Electrical test is done after 60 min soak. Test includes S-parameters measurement (made in the thermal chamber using test cap) and comparison with pre-test measurements.
- Electrical test is done at normal temperature after exposure. Test includes S-parameters measurement and comparison with pre-test measurements.
- For the acceptance tests, vibration is done before electrical parameters test.

Table 6 Vibration Loads for the Acceptance Test

Frequency subbands, Hz	20-40	40 - 100	100 - 300	300 - 600	600 - 1200	1200 - 2500
Acceleration spectral density, g^2 / Hz	0,02-0,25	0,25	0,25	0,25-0,1	0,1-0,03	0,03-0,01
Amplitude for sinusoidal sweep, g	1,0-4,7	4,7-7,5	7,5-13,0	13,0-7,5	12,0-9,0	9,0-7,5

Duration no less than 2 minutes per octave in each of the three directions.

7 Safety

The Antenna does not contain energy sources, batteries, radioactive materials does not pose electrical hazard. The Antenna will not emit any hazardous substances under normal operating conditions defined in this datasheet.

Operating the antenna with RF power source (e.g. transmitter) may impose additional safety conditions.

7.1 Utilization

The Antenna is not RoHS compatible and contains Pb and other non-compliant substances which can be hazardous to the human body and the environment. Observe government laws and company regulations when discarding this product. The Antenna must be discarded in accordance with methods specified by applicable hazardous waste procedures.

8 Disclaimer

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