Antennas and front-ends for GNSS receivers

RUAG Space antennas for satellite-born GNSS receivers are all designed to minimize satellite body interaction. We offer helix and Patch Excited Cup (PEC) antennas. The L-band helix has very low back radiation and can be used where the height is not a limiting factor. The PEC antenna can be delivered with or without corrugations where the first one is a high performance version with further improved back radiation. High performance front-ends, LNA’s and diplexer/filter, are available for the different GNSS frequency bands.

**GNSS Helix Antenna**

This quadrifilar helix design exhibits extremely low back radiation in order to minimize satellite disturbances. To achieve this, a special feeding technique reducing the back radiation by 5 - 10 dB is used. The antenna design is patent protected.

The antenna operates at GNSS frequencies from 1.176 GHz (L5/E5a), 1.227 GHz (L2) to 1.575 GHz (L1/E1) and it has a hemispherical coverage.

The antenna diameter is 90 mm, the maximum height is 410 mm and the mass is 815 g. It has a female TNC connector as RF interface.

Typical measured radiation pattern performance of the antenna is shown below; min/average/max gain envelope over the hemisphere for co- and cross-polar radiation.

Radiation patterns for GNSS Helix Antenna, L5/E5a, L2 and L1/E1 frequencies
**Extended GNSS PEC Antenna**

If you need improved performance with reduced spacecraft illumination, lowered cross-polarization and also reduced omni variation, the extended PEC antenna is your choice. The antenna is well suited for precise orbit determination (POD) applications, where antenna phase center stability is essential.

The antenna operates at all GNSS bands, from L5/E5a, E5b, L2 to L1/E1, and it has a near hemispherical coverage.

The antenna diameter is 200 mm, the maximum height is 87 mm and the mass is 735 g. It has a female SMA connector as RF interface. The SMA interface can face either sideways or directly into the spacecraft, i.e. possibility to use a straight or a 90 degree bend SMA.

Typical measured radiation pattern performance for the antenna is shown below; min/average/max gain envelope over the hemisphere for co- and cross-polar radiation.

**GNSS PEC Antenna**

For smaller spacecraft where the quadri-filar helix antenna and the extended PEC antenna can be too high, a lower profile antenna is available. It also operates at all GNSS bands, from L5/E5a, E5b, L2 to L1/E1. It is a PEC antenna with highly stable RF performance over the GNSS frequency bands.

The antenna diameter is 160 mm, the maximum height is 55 mm and the mass is 325 g. It has a female SMA connector as RF interface.

It is designed to cope with very demanding vibration loads, as normally used for boom mounted TT&C antennas.

This antenna can be used together with the GEO PEC antenna for GEO missions, transfer orbit (GNSS PEC antenna) and on station (GEO GNSS PEC antenna).

Typical measured radiation pattern performance of the antenna is shown below; min/average/max gain envelope over the hemisphere for co- and cross-polar radiation.
**GEO GNSS PEC Antenna**

This antenna is aimed towards use on geostationary orbit (GEO) satellites. It is also a PEC antenna, but with increased boresight gain.

The antenna operates at the GNSS L1/E1 band (also capable of Glonass G1 use).

The antenna diameter is 239 mm, the maximum height is 179 mm and the mass is 715 g. It has a female SMA connector as RF interface.

This antenna can be used together with the GNSS PEC antenna (or the L1 PEC antenna) for GEO missions, transfer orbit (GNSS PEC antenna) and on station (GEO GNSS PEC antenna).

**L1 PEC Antenna**

For missions and applications requiring single frequency antenna with low mass and volume this antenna is a very good choice. It is also a PEC antenna.

The antenna operates at the GNSS L1/E1 band and is also capable of Glonass G1 use.

The antenna diameter is 144 mm, the maximum height is 35 mm and the mass is 220 g. It has a female SMA connector as RF interface. The SMA interface faces directly into the spacecraft.

**Test caps**

Test caps/hats are available to all our GNSS antennas. The caps/hats for all antennas, except the L1 PEC antenna, are absorptive with a set coupling value (e.g. 10, 15, 20 dB etc.). The L1 PEC antenna test cap/hat is of a 0 dB coupling type.

![GEO GNSS PEC antenna](image1)

Typical measured radiation pattern performance of the antennas is shown below; min/average/max gain envelope over the hemisphere for co- and cross-polar radiation.

![Radiation pattern for GEO GNSS PEC antenna, L1/E1 frequency](image2)

![L1 PEC antenna](image3)

![Radiation pattern for L1 PEC antenna, L1/E1 frequency](image4)

![GNSS Helix test cap/hat for ambient use](image5)

![GNSS PEC test cap/hat for TVAC use](image6)

![L1 PEC test cap/hat for TVAC use](image7)

![Extended GNSS PEC test cap/hat for TVAC use](image8)

![GEO GNSS PEC test cap/hat for TVAC use](image9)
GNSS Receiver Front-ends

RUAG Space has a range of GNSS receiver front-end products available and can further tailor variants if needed. The noise figure is excellent, based on low noise GaAs transistors giving simultaneous good return loss and excellent gain flatness. The LNAs are equipped with preselection filters, bandpass or multibandpass, custom made to different bandwidth, rejection & group delay requirements. Notches at radio frequency interferer frequencies can be added, for example Search&Rescue, as well as broadband lowpass filtering of e.g. X-band signals. The units can be delivered with black surface treatment for increased thermal emissivity when needed.

To date, more than 130 flight units have been delivered!

**Existing models:**

![L10](image1.png) ![L20](image2.png) ![L30](image3.png)

**L10** has a single-frequency front-end. The GNSS L1/E1-signal is input to a bandpass filter. The signal is then amplified. +9V unregulated DC-power is received though the coaxial RF-output connector. A power conditioning board creates the necessary voltages for the RF-amplifier including linear regulation, filtering and transient protection. The electrical interface is one input and one output SMA connector.

**L20** has a dual frequency front-end. A diplexer separates the GNSS L1/E1 and L2 signals from the common antenna port into two bandpass filters. The L1 and L2 signals are amplified in separate amplifiers. Linearly regulated and filtered +5V and -5V DC is received though the coaxial RF-output connectors. The electrical interface is one input and two output SMA connectors.

**L30** has a triple-band selectivity front-end. The GNSS L1/E1, L2 and L5/E5a signals are input to a common port on a multibandpass filter. The bands are filtered individually, low noise amplified and output in a common port. +9V unregulated DC-power is received though the coaxial RF-output connector or a D-Sub connector. A power conditioning board creates the necessary voltages for the RF- amplifiers including linear regulation, filtering and transient protection. The electrical interface is one input and one output SMA connector.

**LNA Performance Comparison**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>L10</th>
<th>L20</th>
<th>L30</th>
<th>L30, low NF High Gain Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channels (BW)</td>
<td>L1: 1575.42 ± 5 MHz</td>
<td>L1: 1575.42 ± 8 MHz</td>
<td>L1: 1575.42 ± 8 MHz</td>
<td>L1: 1575.42 ± 4 MHz</td>
</tr>
<tr>
<td></td>
<td>L2: 1227.60 ± 10.23 MHz</td>
<td>L2: 1575.42 ± 4 MHz</td>
<td>L2, L5 incl. E5b: 1200.5 ± 7.5 MHz</td>
<td>L5: 1176.45 ± 7.5 MHz</td>
</tr>
<tr>
<td>Noise figure of unit (total incl. Pre-selection filters in high temp)</td>
<td>L1 meas: 1.9 dB @ 22°C L1 meas: 1.4 dB @ 22°C L1 meas: 2.2 dB @ 65°C</td>
<td>L1 meas: 1.7 dB @ 65°C L2, L5 incl. E5b meas: 2.3 dB @ 65°C</td>
<td>L1 meas: 2.2 dB @ 65°C L2, L5 incl. E5b meas: 2.3 dB @ 65°C</td>
<td>L1 meas 1.6 dB @ 60°C L5 meas 2.0 dB @ 60°C</td>
</tr>
<tr>
<td>Gain (total)</td>
<td>27 dB ± 1 dB</td>
<td>25.5 dB ± 1 dB</td>
<td>33 dB ± 1 dB</td>
<td>37 dB ± 1 dB</td>
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