Antennas and front-ends for GNSS receivers

RUAG Space L-band helix antennas for satelliteborn GNSS receivers are designed to minimize satellite body interaction while RUAG’s Patch Excited Cups (PEC’s) are the choice when height is the limiting factor. RUAG Space also offers a PEC version with corrugations which improves back radiation further. High performance front-ends, LNA’s and diplexer/filter, are available for different GNSS frequency bands.

Our products are originally developed for GPS and Galileo use, but are of course also possible to use for other navigation systems like Glonass, COMPASS and QZSS. The products are based on many years of experience from antenna and microwave products for telecom payloads and also from microwave instrumentation for scientific purposes.

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 on the left; min/average/max gain envelope over the hemisphere for co- and cross-polar radiation.
**GNSS PEC Antenna**

For smaller spacecraft where the quadrifilar helix antenna can be too high, a low profile antenna is available. It also operates at GNSS frequencies, from L5/E5a, E5b, L2 to L1/E1.

It is a PEC (Patch Excited Cup) antenna which consists of two patches placed in a circular cup. To achieve highly stable RF performance over the GNSS frequency bands we have used a four-point feed with capacitive coupling of the bottom patch and an isolated feed network.

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. 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.

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**Extended GNSS PEC Antenna**

This is a PEC antenna that has been extended with two corrugations which improves the performance by further reducing the spacecraft illumination, lowering the cross polarisation and also reducing the omni variation. The antenna is well suited for precise orbit determination (POD) applications, where antenna phase center stability is essential.

The antenna operates at GNSS frequencies, 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.

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.
Radiation patterns for Extended GNSS PEC antenna, L5/E5a, L2 and L1/E1 frequencies

GEO GNSS PEC Antenna
This is the latest member in our GNSS antenna family. It is aimed towards use on geostationary orbit (GEO) satellites. It is also a PEC antenna, but with one more patch to increase the boresight gain. The antenna operates at the L1/E1 frequency.

The antenna diameter is 212mm, the maximum height is 179 mm and the mass is 560 g. It has a female SMA 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.
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 a hundred flight units have been delivered!

Existing models:

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 through 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 through 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 through the coaxial RF-output 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>GNSS LNA Parameter</th>
<th>L10</th>
<th>L20</th>
<th>L30</th>
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</thead>
<tbody>
<tr>
<td>Channels (BW)</td>
<td>L1: 1575.42 ± 5 MHz</td>
<td>L1: 1575.42 ± 10.23 MHz</td>
<td>L1: 1575.42 ± 8 MHz</td>
</tr>
<tr>
<td></td>
<td>L2: 1227.60 ± 10.23 MHz</td>
<td>L2 1227.60 ± 10.23 MHz</td>
<td>L2, L5 incl. E5b: 1200.5± 40 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</td>
<td>L1 meas. 1.4 dB @ 22°C</td>
<td>L1 meas. 2.2 dB</td>
</tr>
<tr>
<td></td>
<td>L1 meas. 2.3 dB @ 65°C</td>
<td>L1 meas. 1.7 dB @ 65°C</td>
<td>L2, L5 incl. E5b meas. 2.1 dB</td>
</tr>
<tr>
<td>Gain (total)</td>
<td>27 dB ± 1 dB</td>
<td>25.5 dB ± 1 dB</td>
<td>33 dB dB ± 1 dB</td>
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