SPACE HAUC: Satellite Radios

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Abstract

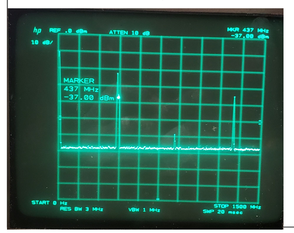
- A spacecraft's communication system enables spacecrafts to transmit data and diagnostics to Earth, receive commands from Earth, or relay information between other spacecraft. NASA highlights commercial-off-the-shelf (COTS) communications systems that operate in different communication bands, with Ultra High Frequency (UHF) as the most commonly selected band.
- SPACE HAUC is an educational 3U cube satellite mission demonstrating high data transmission rates beyond the S band, accomplished with a steerable X-band phased array system.
  - This novel radio, designed by students, is the primary payload of technology demonstration
  - An additional standard radio is selected to monitor the primary payload and to act as a fail-safe.
  - Two options operating in the frequently selected UHF band are EnduroSat's UHF transceiver and Planet Labs' OpenLST radio system.
- SPACE HAUC will demonstrate high rate data transmission (up to 100 Mbps) which is essential for imaging applications that dominate nanosatellite missions.

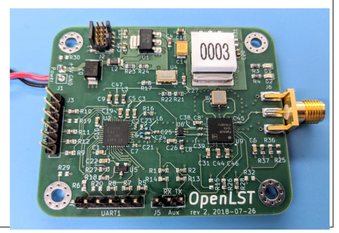
Goals

- 50 Mbps downlink communication data rate; stretch goal of 100 Mbps
- Adaptive beam steering: direct the radio signal beam to earth station without physically moving the satellite
- Flight proven fail-safe communication system with omni-directional antenna

Planet Lab's OpenLST

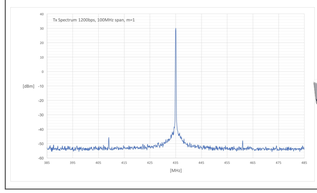
- Open Source system:
  - Full design files, including schematics, bill of materials, layout, and firmware
  - Operational in Space Research UHF band
- Downlink: 401.3 MHz at 3.5 kbps data rate with 1W transmitter RF power
- Uplink: 450 MHz at 3.5 kbps data rate with -112 dBm receiver sensitivity
- Antenna: Tape measure dipole
- Cost: $1000





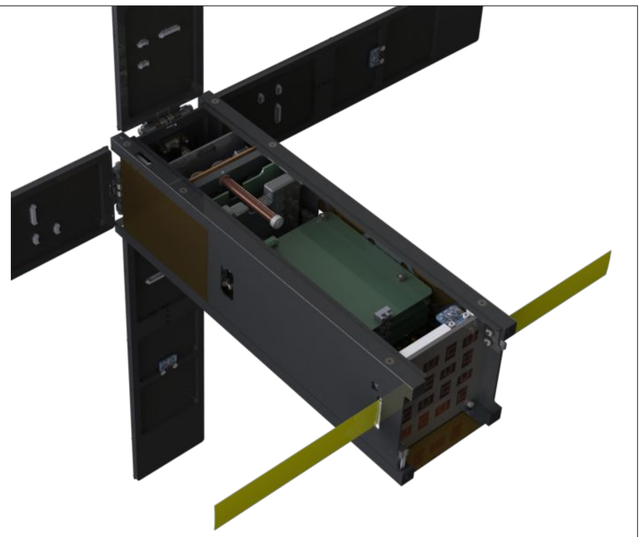
EnduroSat's UHF Transceiver II

- Flight proven COTS system:
  - Designed and sold by EnduroSat
  - Operational in ammature UHF band
- Downlink: 435-438 MHz at 9.6 kbps data rate with 1W transmitter RF power
- Uplink: 435-438 MHz at 9.6 kbps data rate with -121 dBm receiver sensitivity
- Antenna: Tape measure dipole
- Cost: $5000



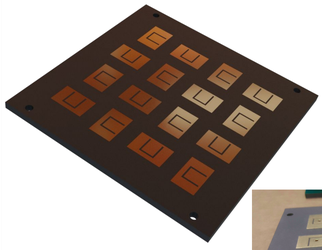
Developments

- X-band communication system is completed and undergone preliminary testing; results are better than expected:
  - A single link of the 16 elements was tested using IC components on evaluation boards; expected output power was 19.5 dBm, and test results output was 21 dBm
  - Patch antenna array VSWR was tested:
    - Result: less than 1.7:1 VSWR in 7 to 8.5 GHz range
  - Final RF boards are currently being manufactured
  - The complete system will be tested next month.
- Fail-safe communication system:
  - Decided to move forward with EnduroSat UHF system.
  - Currently working towards final integration of EnduroSat system
  - OpenLST system is still being developed as a cheap fail-safe system alternative for future missions



X-Band Communication System

- It operates in the X-band (7.2 - 8.3 GHz) and uses a 16 element (4 x 4) patch antenna array.
- The phased array will create a 25º (FWHM) beam and will also demonstrate beam steering over ± 45º with less than 5º error.
- The X-Band communication system consists of COTS radio; and student designed patch antenna array, RF front-end module for signal processing and beam steering.
- The system occupies a 1.5U volume and weight less than 1 Kg. Its transmitter and receiver consume approximately 9W power each; transmit RF power is 1.6 W with a receiver sensitivity of -115 dBm.
- A patch antenna array is designed to resonate in wide-band frequency with high gain, and with beam steering capability.



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