Deployable Crossed-Dipole Antenna for CubeSat Uplink and Downlink

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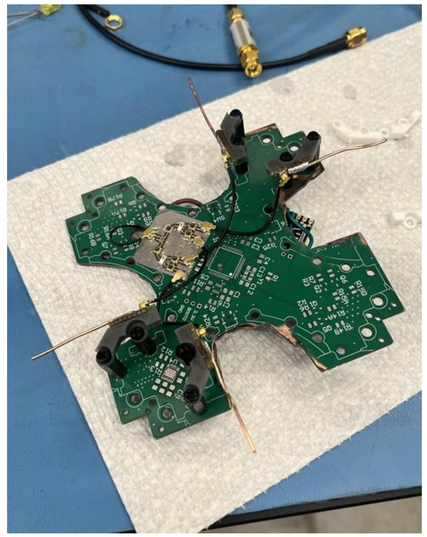
Background

Across industries, research and development into space technologies has been greatly increasing. Cubesats are a small, cost-effective satellite format for researchers and industry professionals to experiment with new technologies. However, developing Cubesats is difficult, due to their small size constraints and necessity for space-grade hardware. This project is an open-source Cubesat antenna and radio system intended to hasten the development of space hardware. The system is built for the LoRa modulation technique on the 915MHz ISM band.

Methodology

The antenna was constructed of a custom printed circuit board with SLA 3D printed fixtures to secure the antennas in place. The printed circuit board houses the microwave circuit, microcontroller for deployment control, and supporting electrical hardware for antenna deployment. After it was constructed, it was flown on a weather balloon while it beaconed continuously at 27dBm transmit power. On the ground, the researcher measured received signal integrity, signal to noise ratio, and frequency error.



On the left is the final antenna before launch. Cuts were made in the PCB to properly tune the antennas for 915MHz. On the right is a photo of the balloon right before launch. To the left of the balloon is a string of the research payloads being launched on the balloon.

Results

During construction, image theory effects with the ground plane on the PCB caused the antennas to not tune properly. As such, a bandsaw was used to cutout large chunks of the PCB to mitigate the ground plane effects. After this, an effective tune was achieved. During bench testing, the antenna performance was similar to an omidirectional antenna. During the launch, only one packet was received, with an RSSI of -128dBm, an SNR of -2dB, and a frequency error of -6420.96 Hz, at an approximate distance of 2.8-4.3 km.

Conclusion and Future Research

The antenna was less performant than expected; only receiving one packet at roughly three kilometers of distance, which will not be enough for a satellite in low earth orbit. This poor performance may be attributed to pointing and polarization losses. More research is needed to be done to mitigate the image theory effects, as well as see its performance in space.

References

[1] J. Costantine et al., "UHF Deployable Helical Antennas for CubeSats," in IEEE Transactions on Antennas and Propagation, vol. 64, no. 9, pp. 3752-3759, Sept. 2016
[2] S. M. Yayan, "Wideband Circularly Polarized Low Gain Turnstile Antenna for Cube-Sat Tracking Applications at UHF-Band," 2023 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting (USNC-URSI), Portland, OR, USA, 2023, pp. 1735-1736

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