A Thin and Conformal Rocket Antenna for LoRa Communications

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Abstract

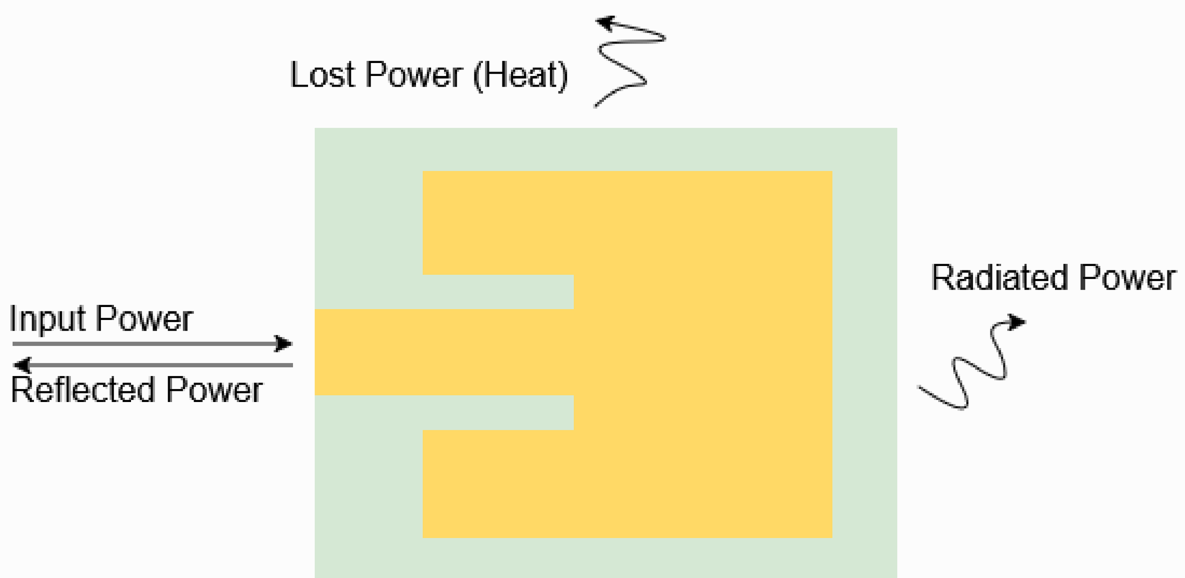
With the development of new carbon-fibre rockets, thin antennas that can be embedded into a rocket shell are required. This Capstone delivers such an antenna for telemetry communications over the 915 MHz LoRa band. It explores the use of a “double tuning effect” to expand a microstrip patch antenna’s bandwidth while maintaining its thinness and conformability.

Introduction

The RMIT High Velocity (HIVE) rocket team is a student club dedicated to building rockets for university competitions. The team has had great success winning awards for technical excellence with their latest rockets.

However, their current internal antenna will not receive signal as they upgrade to a new carbon-fibre airframe.

This project delivers a thin external antenna that can be embedded into the airframe. The key challenge was that as patch antennas become thinner, power is reflected off the antenna and their bandwidth (the range of frequencies they can operate on) shrinks.



When power is input into an antenna, a portion is reflected back, another portion is lost as heat and the rest is transmitted as a useful signal. This reflected power (called the return loss) is the limiting factor in a thin antenna’s bandwidth.

Antenna Requirements

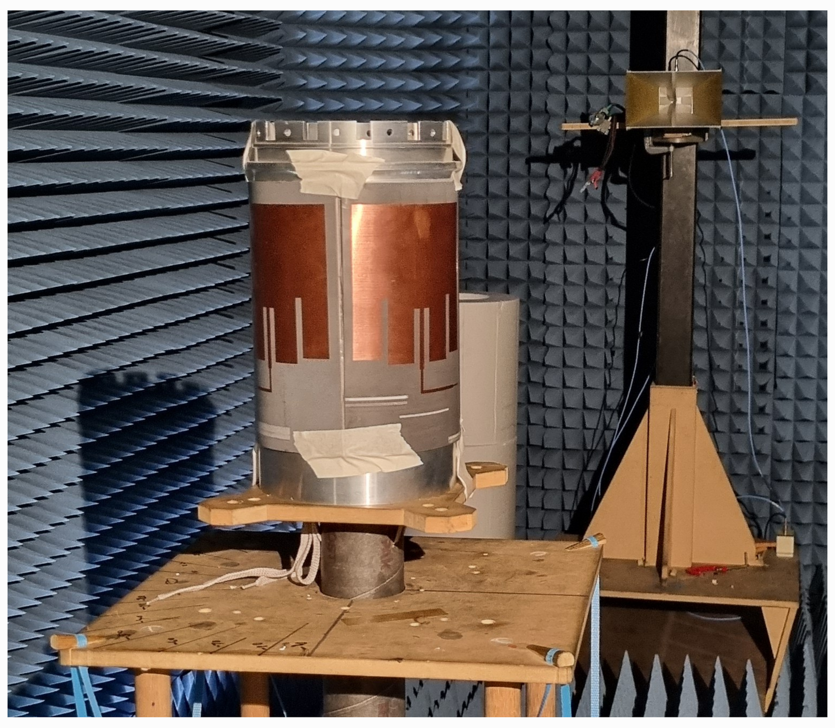
The antenna must support communications over the 915 MHz LoRa band. Additionally, to fit within the shell and avoid requiring significant reinforcement, only a 1.6 mm thick antenna is allowed. To provide reliable reception, the antenna must transmit and receive almost equally in all directions (called an isotropic radiation pattern).

Characteristic	Target Value
Centre Frequency	915 MHz
Minimum Bandwidth	26 MHz (902-928 MHz)
Maximum Return Loss	-8 dB
Target Thickness	1.6 mm
Target Radiation Pattern	Near-isotropic

While the industry standard acceptable portion of power being reflected is 10% (called a return loss of -10 dB), this project required a raised limit of 15% (a return loss of -8 dB). The LoRa module can handle up to 25% power reflected meaning this is acceptable.

Antenna Solution

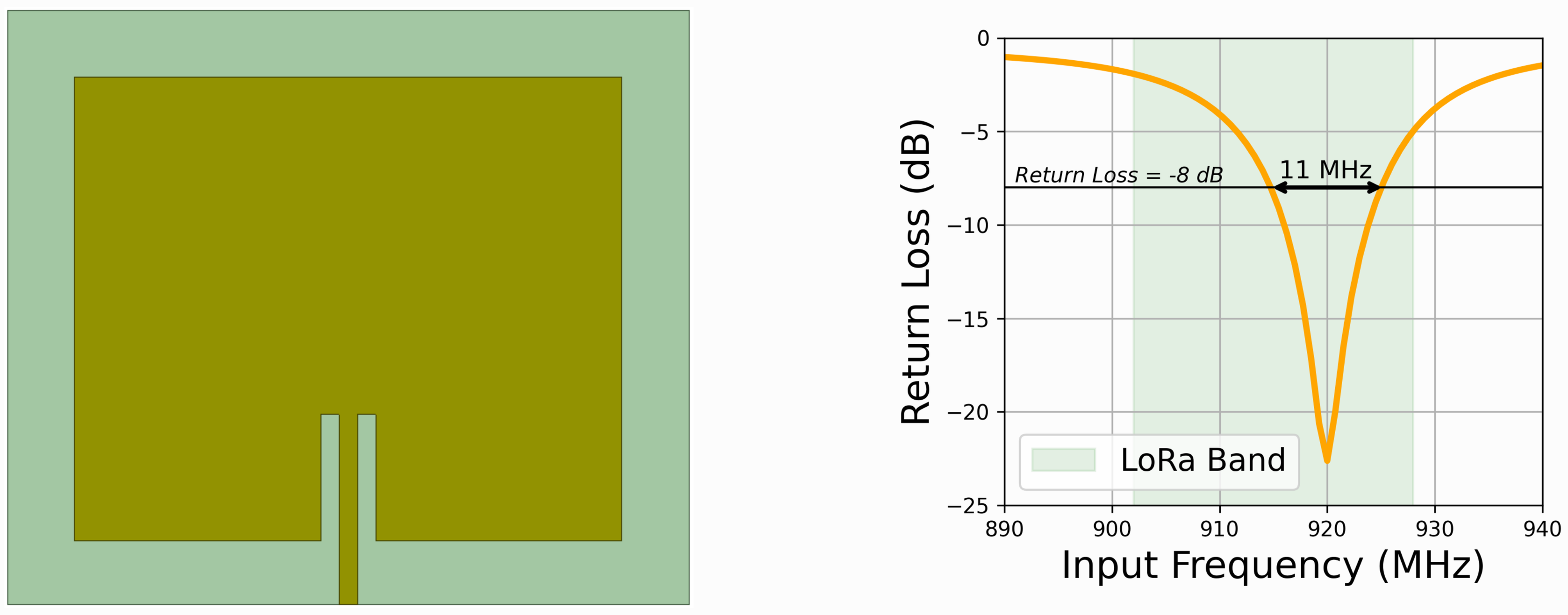
A microstrip patch array was chosen as the most suitable antenna type for its thinness, ease of manufacturing and design flexibility. It was printed on a Rogers 5880 substrate to allow conforming to a cylinder.



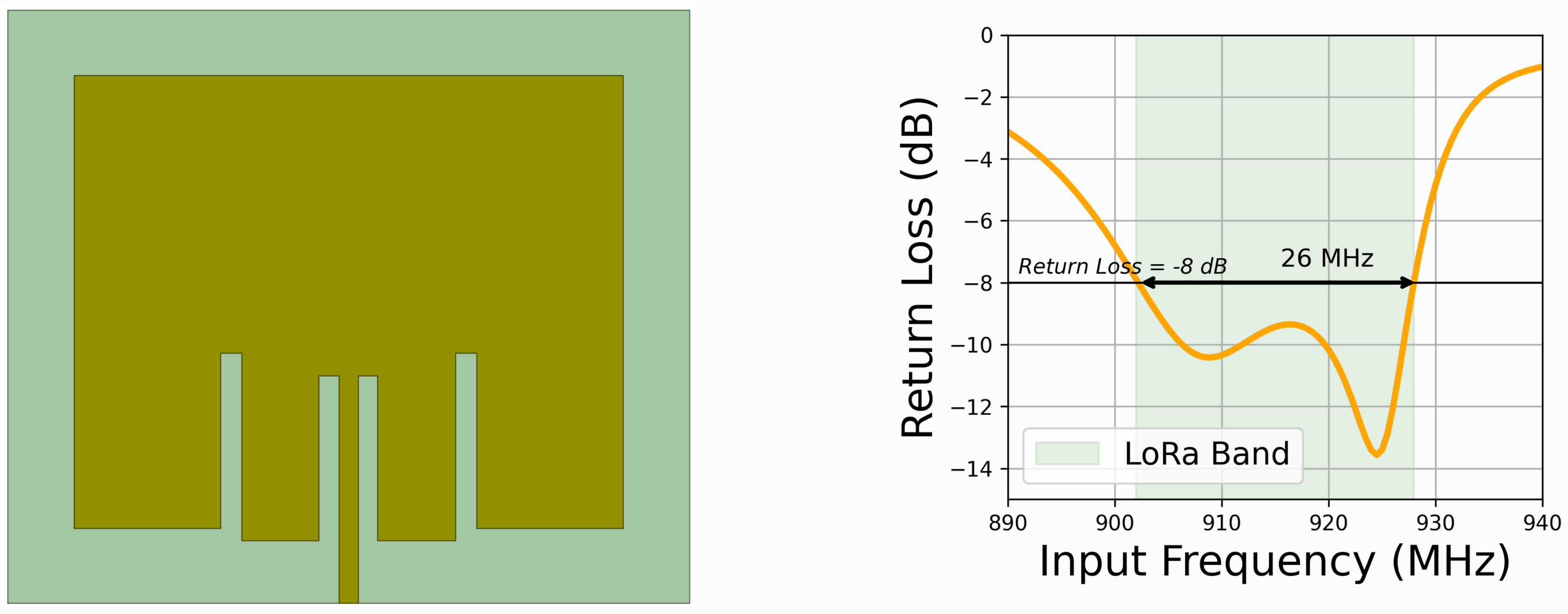
The microstrip patch array was tested for its return loss and radiation pattern after manufacturing.

Bandwidth Improvement

A standard microstrip patch design has a limited bandwidth, meaning that when transmitting some frequencies, significant power was reflected. A modified E-shaped patch [1] was used to produce a “double tuning effect” [2], doubling the bandwidth.



The basic patch has a return loss curve with many frequencies in the LoRa band above –8 dB meaning over 15% of the input power is being reflected back to the transmitter. This isn’t an acceptable design.

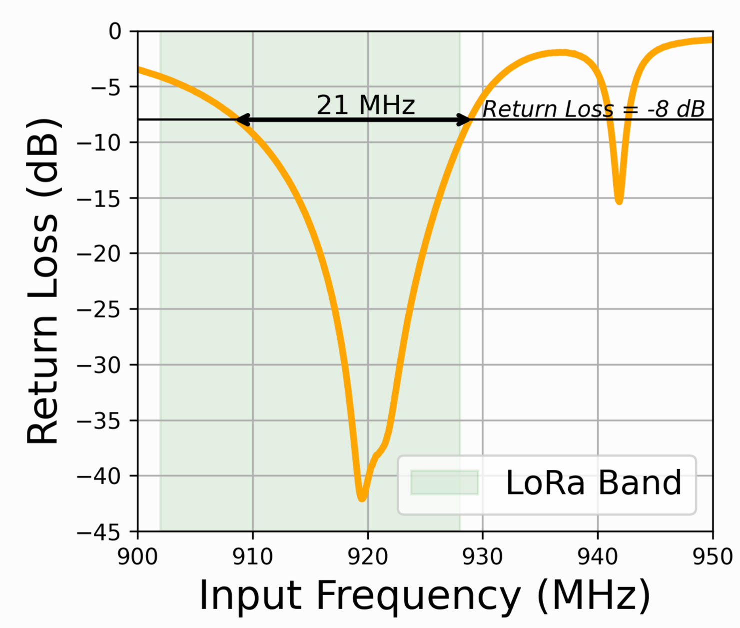


The E-shaped patch return loss is under –8 dB for all LoRa frequencies. The two minima in the reflected power shows the double tuning effect.

Prototype Testing

A physical prototype of the patch array was manufactured and tested in the RMIT anechoic chamber. It covered 70% of the LoRa band and had a near-isotropic radiation pattern.

The manufactured antenna had increased an increased nearer resonant frequencies limiting the bandwidth .



Conclusion

This capstone project has delivered a simulation that meets the requirements and a physical product suitable for Australian use. Multiple tuning of an antenna was shown to be an invaluable tool for improving bandwidth without thickening. A second iteration will correct the resonant frequencies and test the antenna in a carbon-fibre shell and real-world conditions.

Acknowledgements

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References

[1] R. Gatti, R. Rossi, and M. Dionigi, ‘Single-Layer Line-Fed Broadband Microstrip Patch Antenna on Thin Substrates’, Electronics, vol. 10, no. 1, p. 37, Dec. 2020

[2] D. Pozar, ‘Microstrip antennas’, Proc. IEEE, vol. 80, no. 1, pp. 79–91, Jan. 1992