Avian/Airborne Vehicle Notifier

FMCW Radar for Bird Detection

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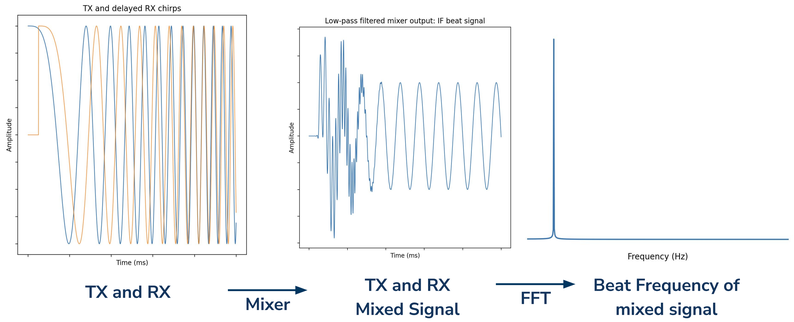
Background

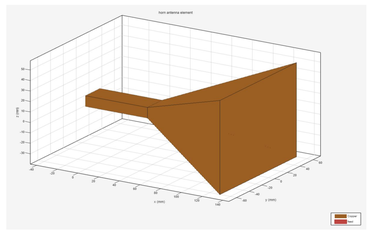
Wind turbines are a terrific source of renewable energy, however, they are difficult to build due to potential impact on local avian populations. By using an automated system to track bird movements, it becomes simple to determine the impact of a building a wind turbine, thus making it far easier to get a turbine built.

Design Specifications

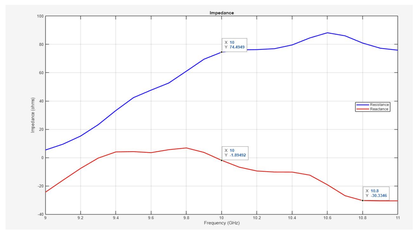
The radar system is designed to detect bird-sized moving targets by estimating both range and radial velocity using an FMCW chirp signal. By comparing the transmitted and received chirps, the system extracts a beat frequency proportional to target distance, while Doppler shifts are used to determine motion toward or away from the radar.



Antenna



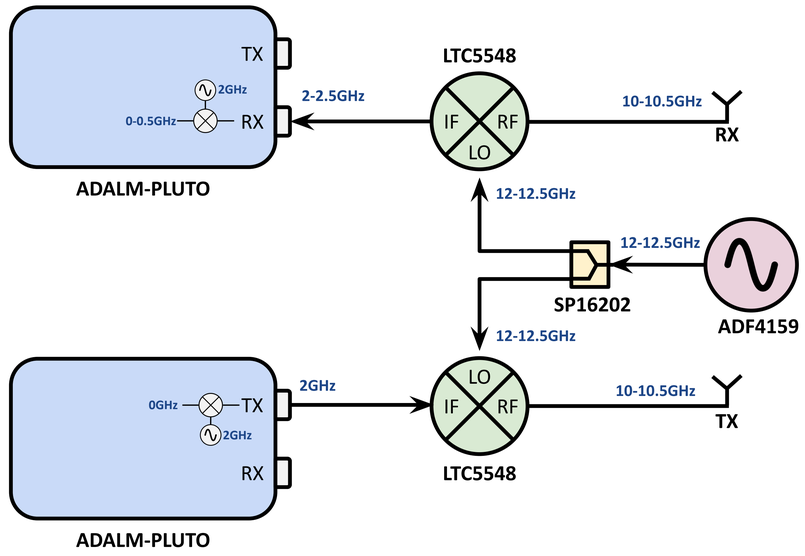
MATLAB Horn Model



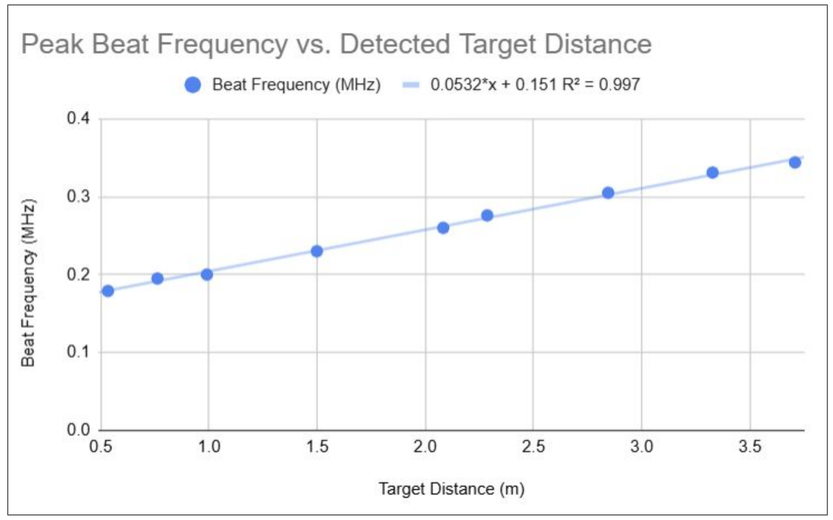
Theoretical Horn Performance

A custom pyramidal horn antenna was designed for X-band operation to increase system gain and improve directional sensitivity. The antenna focuses transmitted and received energy toward the target area, helping the radar detect weaker bird reflections while reducing off-axis noise.

Block Diagram



Results

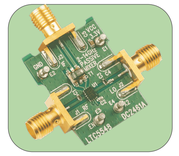


As an object within range of the radar gets further away, the difference in frequency between the transmitted signal and received signal grows at a linear rate. This allows the system to accurately predict range from the received signal.

Hardware

ADALM Pluto - SDR capable of outputting low frequencies of up to 3.8GHz. It is used as a controller and DAC.

ADF4159 - External oscillator capable of chirping at a frequency of up to 13GHz.

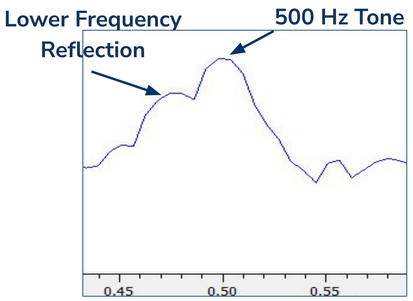


LTC5548 - High speed mixer used to increase the outgoing signal frequency and calculate the beat of the incoming signal.

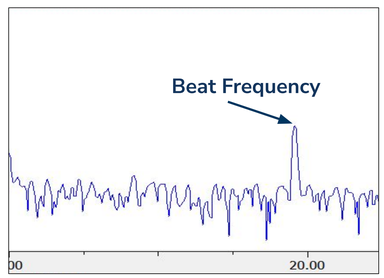
SP16202 - Low noise splitter used to break the oscillator output in two.

ZX60-05113LN+ - Low noise amplifier, used to increase the gain on the incoming signal and lower the noise floor.

Data Processing



Velocity Detection



Range Detection

Samples from the ADALM-Pluto are processed in GNU Radio. An FFT is used to identify beat-frequency peaks. Range is estimated from the beat frequency of the reflected chirp, while velocity is estimated from Doppler-induced frequency shifts around a known tone.

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