A Compact X-Band Collision Avoidance Phased Array Radar System for Unmanned Aerial Systems

Jonathan C. Spencer* and Karl F. Warnick
ECE Dept., Brigham Young University, Provo, UT
jonathanspencer@byu.edu, warnick@ee.byu.edu

Rapid growth in applications of Unmanned Aerial Systems (UAS) over the last decade has created a significant need for compact and efficient sensors. The UAS sector has traditionally been dominated by military applications, but recent growth has been concentrated in civilian applications such as agriculture, film making, search and rescue, delivery, and disaster site recovery. Before UAS can be used commercially, there must be regulations in place to ensure that they will integrate safely with manned air traffic. These regulations will rely on the UAS having a robust "detect and avoid" (DAA) system, which requires a lightweight, low power, onboard sensor.

We present a phased array radar system with compact RF transceiver chains and an on-board FPGA and ARM processor framework. The system consists of a single analog transmitter and four receiver channels that are independently downconverted in a homodyne architecture with the transmitted waveform. The homodyne architecture allows for the use of low rate ADCs, which helps drive down the computational burden of signal processing and overall cost of the system. Independently sampling all channels enables digital formation of multiple simultaneous beams. This increases the complexity of the system as compared to analog beamforming, but adds significant functionality for multiple target tracking and precise bearing determination without the use of mechanical antenna gimbals. Although array processing on such a small platform is challenging, the FPGA framework alleviates much of that by performing FFT and array processing, freeing up the ARM processor to perform target detection and collision avoidance algorithms. The radar and DSP board interface with an autopilot to form a fully integrated collision avoidance system.

The system weighs approximately 1 pound and measures 4in x 2.25in x 1.5in, with connectors to external antennas and DC power. We currently use passive arrays of 4x1 Vivaldi endfire PCB antennas for each array element. The radar functions on the ISM unlicensed portion of X-Band from 10-10.5 GHz. The system requires approximately 5W of DC power and transmits 5dBm RF power. Preliminary results show excellent performance at up to 200m range for small micro UAS sized targets. The range can be extended further with an additional power amplifier.

The presentation will address radar and antenna designs and will give outdoor test results. Phased array processing and beamforming for target tracking and angle of arrival estimation will be discussed. Given the timeliness of civilian UAS applications, this research should inform regulatory developments as UAS are integrated into the commercial airspace.