Designing and Building a Custom Phased Array Network Using Software-Defined Radio

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Today’s world of 5G and IOT devices means increasingly crowded frequency spectrums with multiple devices talking on the same frequency at the same time. To gain an advantage, it is becoming increasingly important for radios to determine the direction of a station and be able to “listen” in that direction to distinguish a specific conversation. Using a network of Time Difference of Arrival (TDOA) radios can achieve detailed directionality and high gain, but current systems are expensive, and thus are only used for industrial and government purposes. I made it my goal to design and build a minimalist, high-frequency receiver capable of TDOA. To keep the cost down, I started from scratch and designed my own receiver. My receiver consists of an antenna, followed by a 1MHz high-pass filter to stop broadcast-interference, a variable low-noise amplifier, which is mixed with a local oscillator, followed by a 10KHz low-pass audio filter. The audio frequencies are sampled by a 10-bit ACD and read by an ESP32 microcontroller. The microcontroller, programmed in C using the Arduino IDE, timestamps the data with a GPS signal, packetizes the samples and sends them in real-time over Wi-Fi using UDP. I wrote a signal-processing algorithm using the open source GNU Radio platform that runs in Python. The program turns the raw samples into a frequency graph, waterfall display, and demodulated audio. I successfully designed and built an HF receiver with parts totaling less than twenty dollars. Using this receiver I demonstrate measurement of the speed of light, atmospheric conditions, and recovery of signals below the noise floor.

Awards Won:
Third Award of $1,000