Improved Candar

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Abstract

This paper describes the low cost COTS (commercial off the shelf) radar designed by a team of colleagues at SRC, Inc. as an entry to the IEEE Antennas and Aerospace Systems Society (AESS) Radar Challenge [1] to be held at the 2020 IEEE International RADAR Conference [2]. Our goal is to improve upon the design of the MIT Coffee Can Radar for live operation and Angle of Arrival Estimation.

The Challenge

The AESS Radar Challenge requires entrants to construct a "home brew" radar made from COTS materials that is able to sense multiple targets in a room concealed behind a curtain. The goal is to detail the scene as accurately as possible.
The targets will be a mix of stationary and moving objects, expected to include calibration spheres and corner reflectors. The room has dimensions of 20m x 8m. The curtain will be as transparent as possible in the RF bands while being highly opaque to light. The radar must measure relevant parameters for a small number of targets. Parameters include location, separation distance and speed, for targets in motion. [1]

The Candar Radar Category

The team is modifying the MIT Coffee Can Radar (Candar). Without physical modification, the radar remains in the Low Cost COTS Radar category. With modifications, the radar would cost over the limit and fall into the State of the Art COTS category

FCC Compliance

The Candar transmits in the 2.4 GHz ISM band, and is FCC Part 15 according to the competition guidelines. We do not intent to introduce new frequencies or transmit capability to the Candar,and will only modify the receiver.

Target Properties

According to the competition guidelines, an operator using the radar should be able to describe the scene behind a curtain which includes calibration spheres and corner reflectors that are both moving and non-moving. Out of the box, the Candar can measure range or doppler. Properties of the targets include type (sphere or corner reflector), x,y,z position, and x,y,z velocity. We intend to improve detection of x,y velocity and range through three main methods: implementing Synthetic Aperture Radar, beamforming, and utilizing custom waveforms for improved stretch-processing. A stretch goal is to describe z position of targets by moving the radar vertically on a rail. Further, we would like to eventually use SAR to map both static and moving targets simultaneously. We also intent do use our own signal-processing pipeline, pulling IQ data straight from the ADC.

Theory Of Operation and Improvements

The Candar uses stretch processing FMCW radar to determine range and unmodulated CW radar to determine doppler for targets. By introducing a second receiver, we can estimate the Angle of Arrival for targets, improving our ability to describe the scene. This is done by looking at the differences in timing between the two synchronized receivers, found by computing the FFT of the received signal mixed with the generated FMCW ramp. The waveform itself could also be improved.

The Candar comes with offline processing scripts written in MATLAB. We also intend to improve this by making live processing scripts that show radar information as it happens. This would include live doppler, ranging, AoA, and SAR, where SAR is conducted by moving the radar.

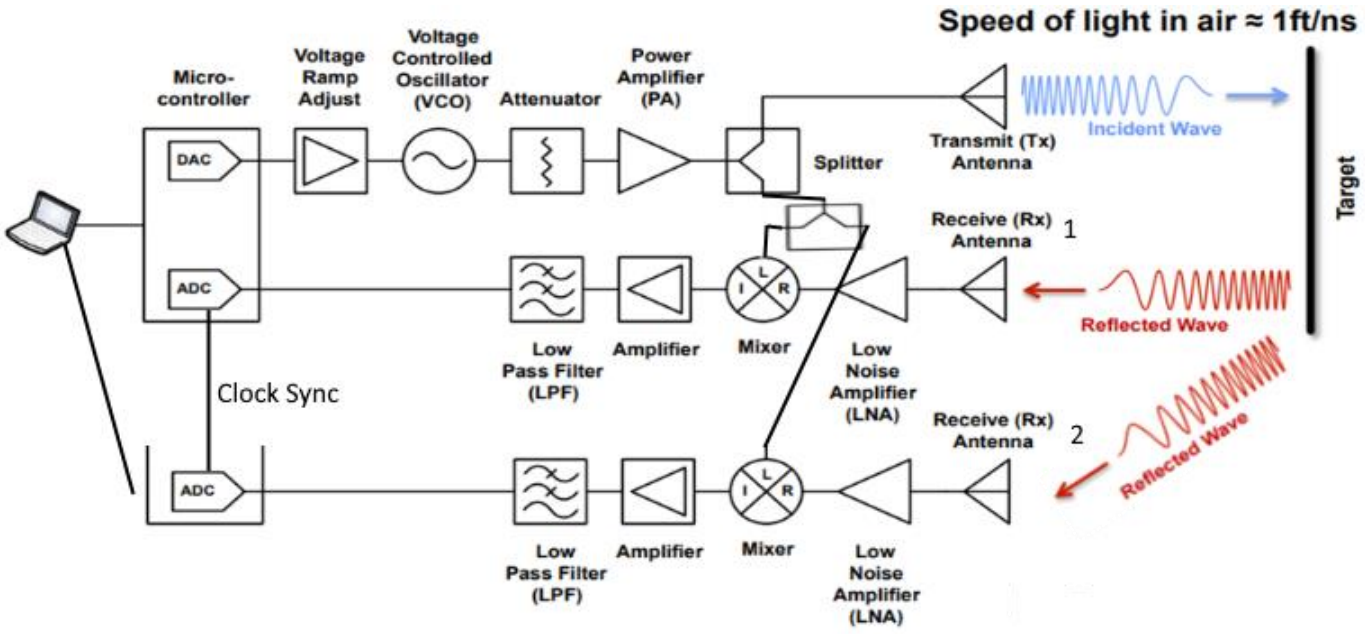

Figure 1: AoA Candar Block Diagram

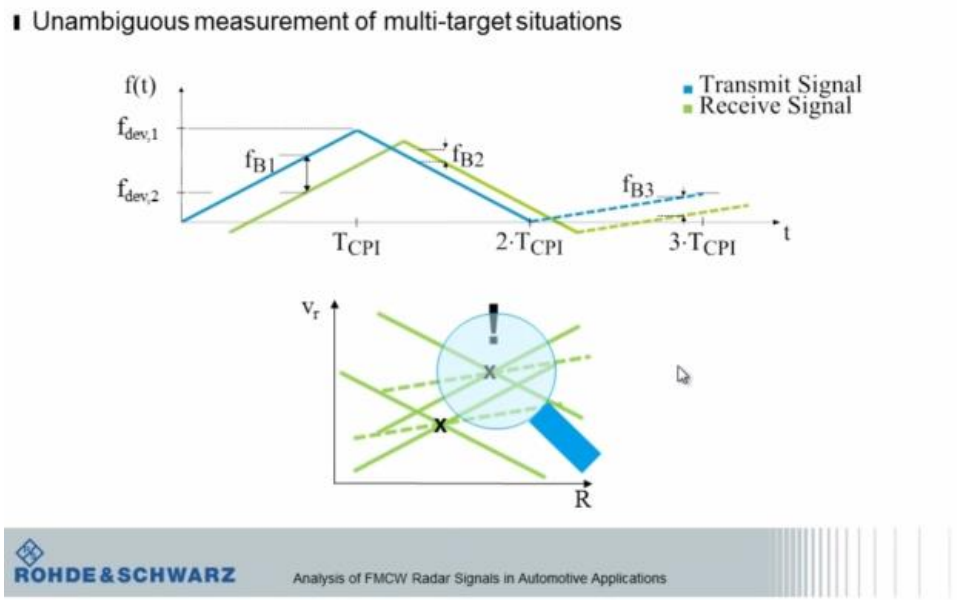

Figure 2: Improved Waveform

Table 1: Improved Candar Bill of Materials

Item #	Part #	Manufacturer	Cost	Description	Notes
1	Candar Kit	MIT Lincoln Labs	$600	Radar Kit	
2	Custom PCB	JLCPCB, SRC, Inc	$50	Baseband Filter Board + components	
3	LNA	Minicircuits	$100		
4	Mixer	Minicircuits	$38.5		
5	Splitter	Minicircuits	$44.99		
		AoA Candar Total=	832.99		

References:

1. http://ieee-aess.org/radar-challenge
2. https://radar2020.org/