The PX-10k: A Polarimetric X-Band Transportable Radar for Rapid-Scan Weather Observations

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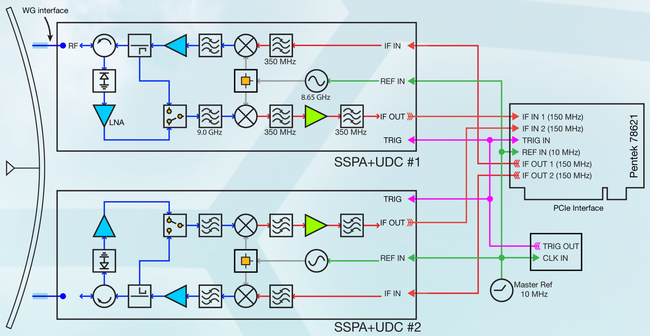
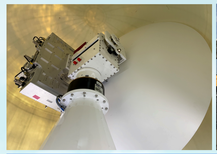
Abstract

A new polarimetric X-band transportable radar, called the PX-10k, was recently developed at the ARRC (Advanced Radar Research Center) of the University of Oklahoma (OU), through a partnership with Nanowave Technologies. Since the development the PX-1000 a decade ago, we have accumulated numerous field experience, which led to a simpler and highly integrated system design. The PX-10k is a transportable system with a built-in power generator and auxiliary fuel tanks that allows for continuous operation without grid power for weeks. This makes the system deployable to remote locations where power may not be readily accessible. The radar system features a 1.4-degree dual-pol reflector antenna, two 800-W solid-state RF transceivers (independent up-down conversion chains), two direct-drive motors as the positioner, and a digital transceiver with arbitrary waveform generator. With a self-contained direct-drive design, the radar needs no gear replacements or routine grease maintenance, which promises less down time and longer lifespan. The system operates on software based on an open-source framework RadarKit, which has been used for the other ARRC radar systems, i.e., the PX-1000 and RaXPol. As such, all waveform capabilities, antenna positioning, and signal processing methods available to these systems are also available to the PX-10k.

System Design

- Highly integrated, single-stage up and down conversions
- Custom FPGA for synchronous timing generation
- Operating frequency can be changed through software by changing the intermediate frequency
- Direct drive, no gear assembly, no routine grease application required



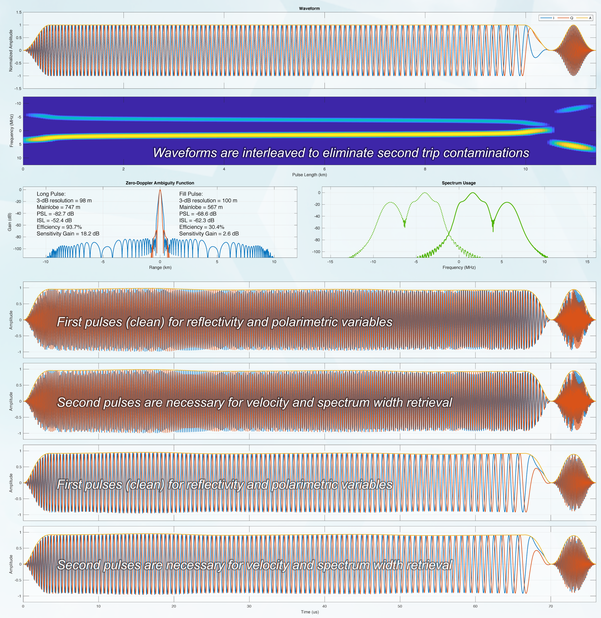


System Specifications

General	
Operating Frequency	8,950 – 9,050 MHz
Operating Pulse Repetition Frequency	100 – 8,000 Hz
Typical Observation Range	90 km
Antenna (Seavey Antenna C0817-810)	
Antenna Gain	42 dBi
Diameter	1.8 m
Beamwidth	1.27˚
Cross-Pol Isolation	>35 dB
Pedestal (Kollmorgen Direct Drives)	
Elevation Coverage	-4˚ to +184˚
Maximum Angular Velocity	360˚s^{-1}
Pointing Precision	0.1˚
Angular Feedback Precision	16-bit
Solid-State Transmitters (Nanowave)	
Peak Power	800 W per Channel
Maximum Pulse Width	100 µs
Typical / Maximum Duty Cycle	14% / 20%
Digital Transceiver (Pentek 78621)	
Intermediate Frequency	300 – 400 MHz
Analog-to-Digital Quantization	16-bit
Receive Bandwidth	Up to 50 MHz
Minimum Gate Spacing	3 m

Waveform Capabilities

- Blind range filling using the time-frequency multiplexing (TFM) method (Cheong et al., 2013, PX1000)
- Frequency hopping to mitigate second-trip contamination



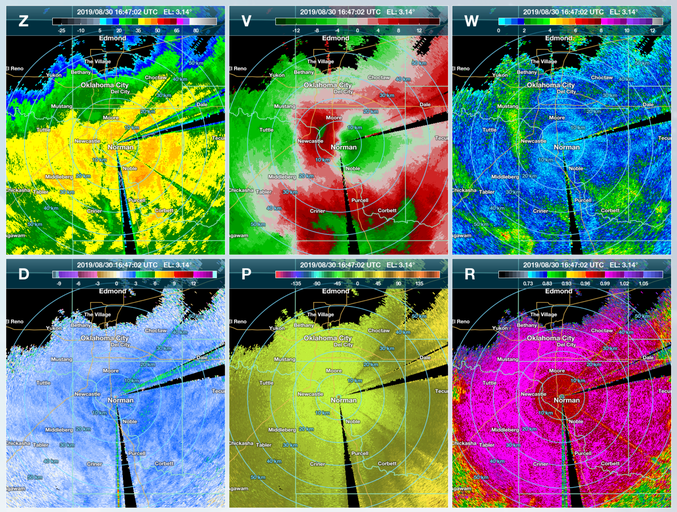
RadarKit + PyRadarKit

- Open source straight C framework
  - Object-oriented like implementation
  - Tested under CentOS, Debian, RedHat, Linux Mint and macOS
- Loosely coupled with transceiver or pedestal

- Crucial components of signal processors
  - Pulse and position integration
  - Matched/mismatched filters
  - FIR/IIR ground clutter filters
  - Data recording and health monitoring
- Common methods that are published in open literature
  - Pulse pair, frequency hopping, spectral, multilag
  - Linear-chirp waveform generation, windowing, software up-down conversions
- High efficiency and high performance
  - Multi-threaded on most modules
  - CPU parallelization through SIMD instructions
  - Tested on an 11-W single-board computer for a 10-MHz sampling system
- Support high-level product generation in Python space through PyRadarKit
  - Example algorithms: attenuation correction, velocity unfolding, etc.
  - Ready to integrate with other Python modules such as PyART and wradlib
- Public repository: https://github.com/ouradar/

Current Field Tests

- System became online since June 2019
- 24/7 operation with shore power and LTE internet connection
- Radar sensitivity and transmitter stability are as expected
- Upcoming work includes intercomparison between nearby S-band and X-band radars



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