bladeRAD

bladeRAD is a novel implementation of a Hybrid active-passive radar system. The system utilizes multiple low-cost Software Defined Radios (SDRs) to create a multi-functional multi-frequency radar transceiver capable of simultaneous active and passive radar sensing. bladeRAD is based off the bladeRF micro 2.0 XA4 SDR that hosts the AD9361 RFIC, capable of RF operation between 70 MHz - 6 GHz. Multiple synchronized SDRs are used in order to carry out the multiple functions and multiple RFs.

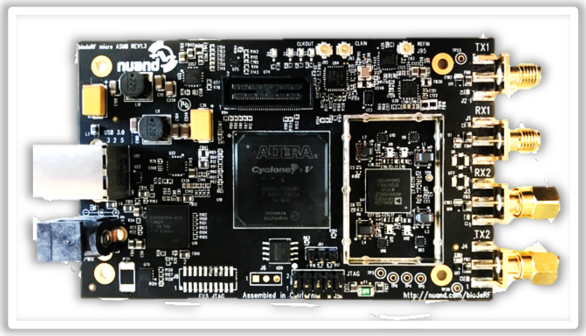

Fig.1 - bladeRF micro 2.0 XA4 Software Defined Radio used in the bladeRAD system.

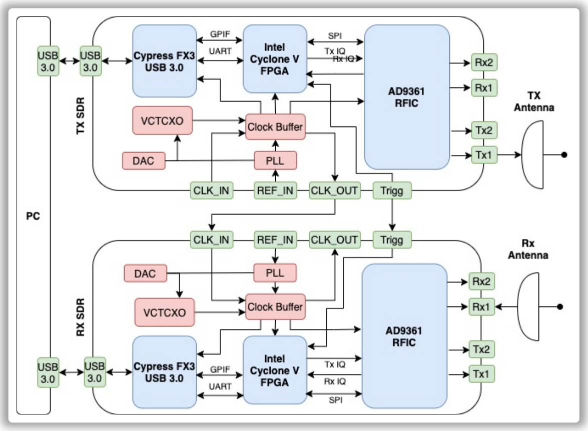

Fig.2 -Transceiver design for active monostatic node utilizing two SDRs; one transmitter SDR and one receiver SDR. The two SDRs are baseband synchronized by sharing a trigger and clock signal from the transmit SDR to the receiver SDR.

Active Transceiver Design

The active transceiver segregates transmit and receive operations across two separate SDRs. This is done to overcome the USB 3 bandwidth limitation between the PC and SDR. The bladeRF CLI is ran on a host PC and used to control the SDR connected through the USB 3 interface. Due to the versatility of the SDR, bladeRAD is capable of both FMCW and Pulse Doppler sensing modes.

Radar Parameter	Value
RF	70MHz – 6 GHz
Bandwidth	40 MHz
Waveform	User Selectable

Active Transceiver Verification

BladeRAD's Pulse Doppler and FMCW sensing modes were first verified using loop-back tests. The first over the air experiments were confined to a small laboratory environment, where a 2.4 GHz (S-Band) RF was selected and the FMCW mode was used (for its close-range sensing ability). The below table lists the radar parameters used. A human target was first captured walking back and forth from the radar. Fig.3 illustrates the spectrogram result.

Radar Parameter	Value
RF	2.45 GHz
Bandwidth	40 MHz
Waveform	Sawtooth LFM
PRF	5 KHz
Tx Power	19dBm
Antennas	18dBi parabolic dish

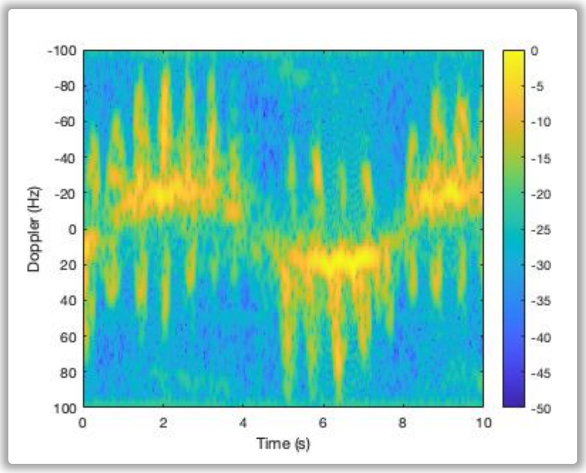

Fig.3 - Spectrogram of human walking back and forth from bladeRAD transceiver operating in (S-Band) FMCW mode. The micro-Doppler resulting from the micro motion of the human's limbs can be clearly observed as periodic streaks around the human's bulk Doppler shift.

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A second FMCW experiment was conducted, though this time capturing a micro-drone slowly flying back and forth from the radar. Fig.4 is the spectrogram result of the micro-drone experiment. Helicopter Rotor Modulation (HERM) lines can be observed as the horizontal lines of Doppler around the micro-Drones bulk Doppler. These HERM lines result from the micro-motion of the drone's propellers.

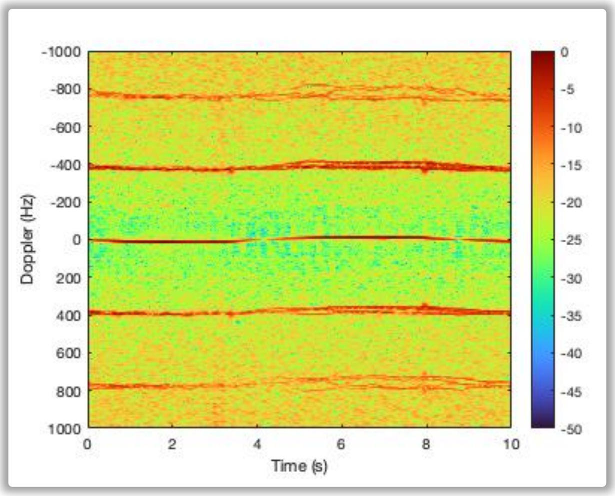

Fig.4- Spectrogram of micro-drone flying back and forth from bladeRAD transceiver operating in (S-Band) FMCW mode. The micro-Doppler resulting from the micro motion of the drone's propellers can be clearly observed as HERM lines with a spacing of approx. $\pm 400Hz$.

Passive Receiver Verification

bladeRAD's operation as a passive radar receiver was verified using a 2.4 GHz Wi-Fi acess point as an Illuminator of Opportunity (IO). The Wi-Fi channel was stimulated using a network traffic generator tool named MGEN. A single bladeRF can be used for a passive radar receiver: one rx channel for sampling the direct path from an IO, and the other for sampling IO reflections from targets. The active transceiver can be developed into a hybrid system through the simple addition of a third SDR for purely passive sensing. Fig.5 is a spectrogram of a human walking back and forth from the passive radar receiver.

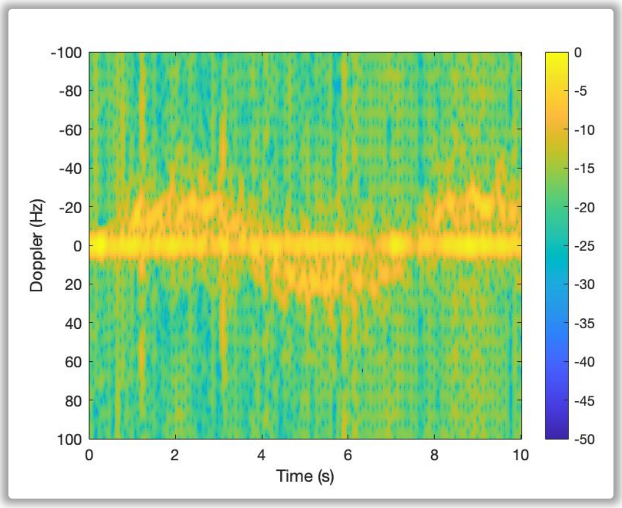

Fig.5 – Spectrogram of human walking back and forth from bladeRAD passive radar receiver using a 2.4 GHz Wi-Fi illuminator of opportunity. The Wi-Fi router was located behind the passive receiver to form a quasi-monostatic geometry.

Radar Parameter	Value
RF	2.437 GHz
Bandwidth	20 MHz
IO Waveform	802.11n (OFDM)
IO Power	20dBm
Radar Antennas	18dBi parabolic dish

Bill of Materials

The table to the right summarizes the main hardware items required to build the bladeRAD hybrid radar system introduced in this document. At the point of this writing this document the author is unaware of any publications on the development of a hybrid active-passive radar system. Through utilizing SDR technology to develop the bladeRAD system, the complexity and cost normally associated with a multifunctional multifrequency hybrid system has been vastly reduced, making hybrid radar research accessible to academic research.

BoM Item	Quantity	Unit Price	Total
Dell XPS 13 Laptop	1	$1444.00	$1444.00
bladeRF 2.0 XA4	3	$480.00	$1440.00
S-Band Passband Filter VBFZ-2340-S+	4	$63.00	$252.00
Amplifier ZRL-3500+	1	$140.00	$140.00
S-Band Antenna HG2418DPD	4	$266.00	$1064.00
Antenna Tripod	2	$20.00	$40.00
		Total	**$4380.00**

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