S_X_MPL
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Electronics
Computers
Communications
TECHNION
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Spectral Coexistence Via Xampling (SpeCX) Prototype

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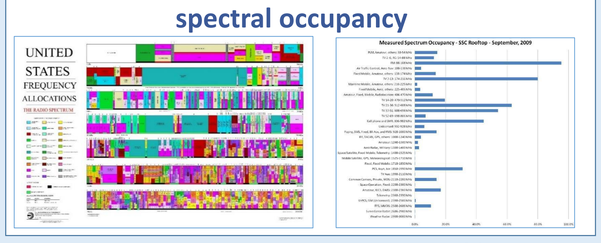
Main Contributions

- A spectrum sharing technology enabling interference-free operation of a surveillance radar and communication transmissions over a common spectrum.
- Cognitive radio (CRo) receiver blind-senses the spectrum using low sampling and processing rates.
- Cognitive radar (CRr) employs a Xampling-based receiver and transmits in several narrow bands.
- We merge two systems and adapt them to solve the spectrum sharing problem.

Spectral Crowding

United States frequency allocation and spectral occupancy

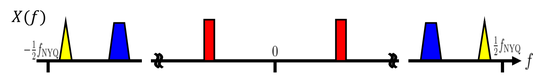


- RF spectrum is a scarce resource and becoming increasingly crowded
- Spectral coexistence exploits spectral underutilization by allowing both radar and comm to share the same resource.

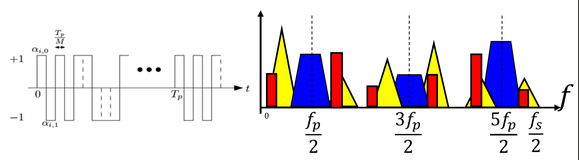
For a wideband signal
Nyquist rate is not an option! → *Sub-Nyquist*

CRo Signal Model

- Input multiband model – $x(t)$ with Nyquist rate f_{Nyq} composed of $2N_{\text{sig}}$ bands each with max bandwidth B.



- The Modulated Wideband Converter (MWC) serves as an analog front-end: M parallel channels alias the spectrum, so that each band appears in baseband.
- Aliasing is done by mixing with periodic sequences:

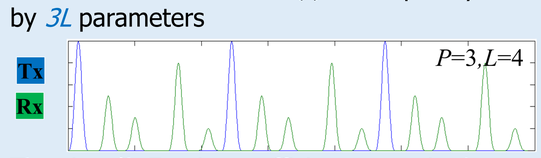


Sub-Nyquist Radar Model

- L targets, each defined by 3 degrees of freedom: amplitude α_ℓ, delay τ_ℓ, and Doppler frequency ν_ℓ
- Received signal for P pulses after demodulation:

$$x(t)=\sum_{p=0}^{P-1}\sum_{l=0}^{L-1}\alpha_l h\left(t-\tau_l-p\tau\right)e^{-j\nu_l p\tau}$$

- This is an FRI model as $x(t)$ is completely defined by $3L$ parameters



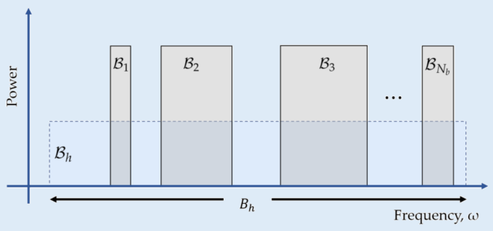
- The signal's Fourier coefficients contain the required parameters:

$$c_p[k]=\frac{1}{\tau}H(2\pi k/\tau)\sum_{\ell=0}^{L-1}\alpha_\ell e^{-j2\pi k\tau_\ell/\tau}e^{-j\nu_\ell p\tau}$$

- Xampling acquires signal's Fourier coefficients that contain the required parameters

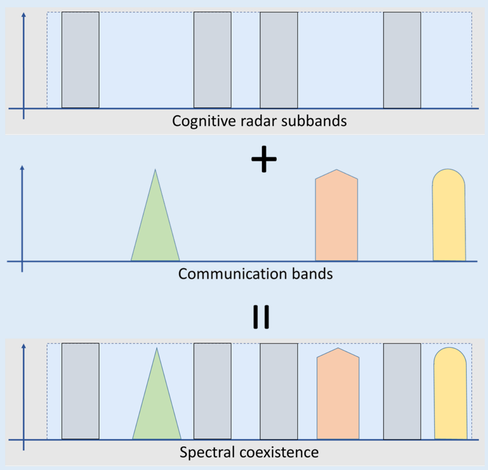
Cognitive Radar

- Cognitive Radar based on sub-Nyquist sampling of receiver
- Leverages sub-Nyquist receiver design
- Advantage of avoiding RF interference from comm services
- Less transmit bandwidth without loss of range resolution
- All Tx power can be focused in narrower bands → high SNR

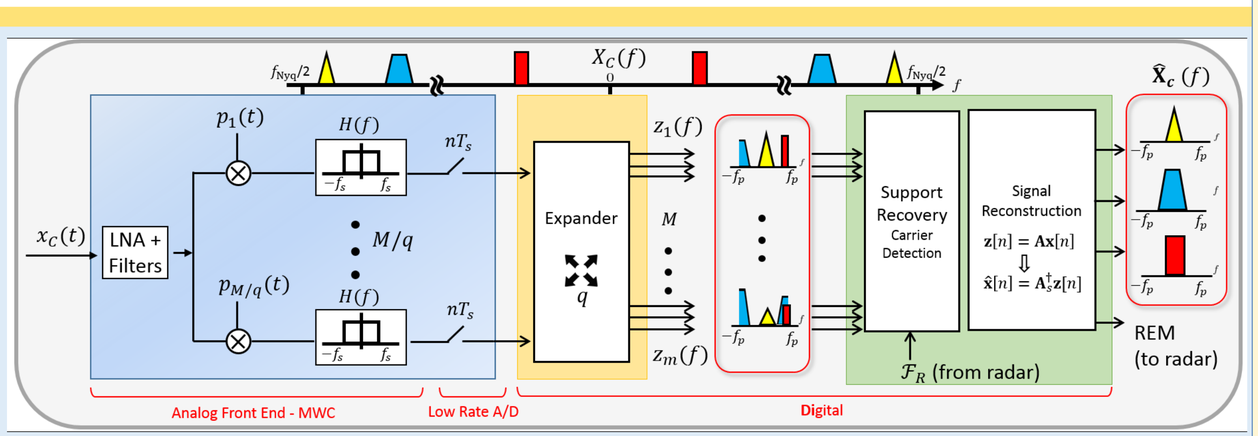


Spectral Coexistence

- The unused CRr bands can be used for comm services

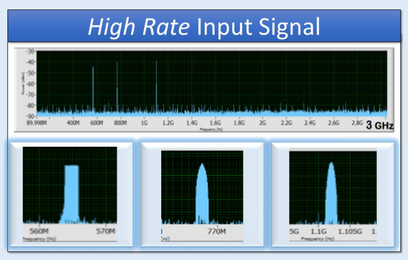


CRo and CRr Spectral Coexistence



- CRo blind senses multi-band comm signals
- CRo communicates vacant band information to the CRr
- CRr chooses the lowest interference sub-bands for transmission

CRo Prototype



Signal Generator

NI© USRP-2942R RF Generator

$x(t)$

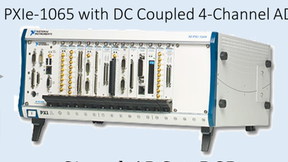
$p_i(t)$

XILINX FPGA – VC707

The MWC Card

NI© PXIe-1065 with DC Coupled 4-Channel ADC

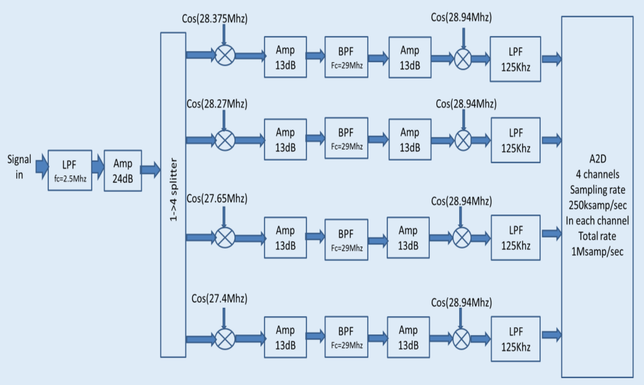
$y_i[n]$



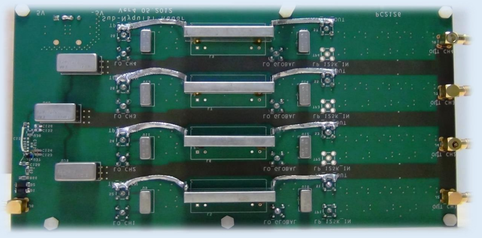
Signal ADC + DSP

CRr Prototype

System Design



Pulse Analog Xampler

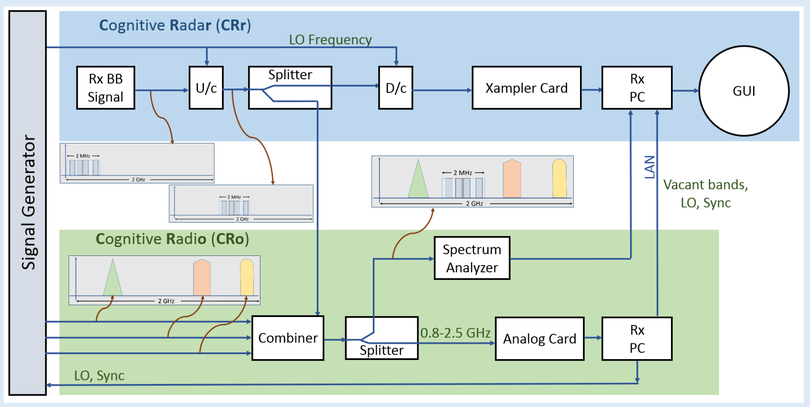


Supporting Hardware – NI System

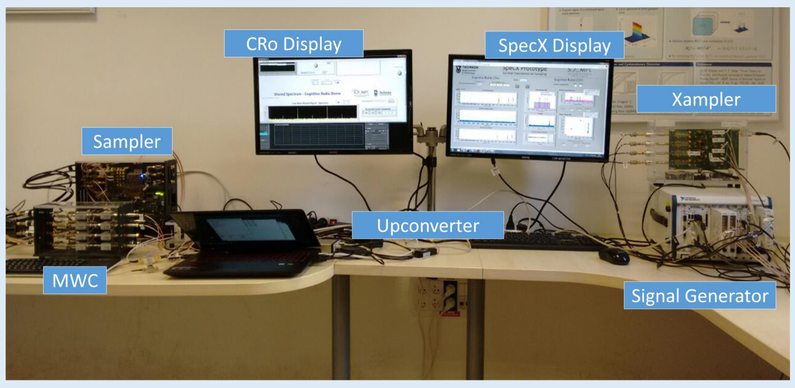
- NI 8133 I7 controller Runs AWR
- NI 5451 Arbitrary Waveform Generator
- NI 5690 RF amplifier
- NI 6123 4 channels ADC, 250 KSps
- NI 4130 Power supply to Pulse Xampler

SpeCX Prototype and Measurement Results

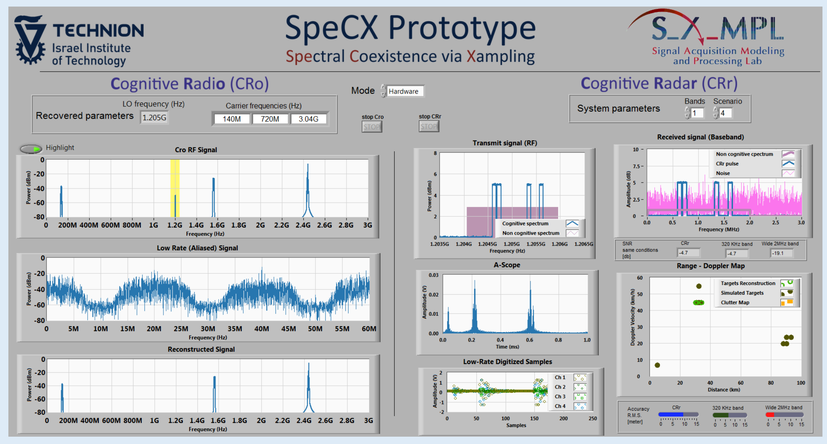
System Design



SpeCX Prototype



Measurement Results



CRo Reconstruction

CRr Detections