Cyclostationary Multiband Signal

- Signal model:
  \[ x(t) = \sum_{i=1}^{N_{\text{sig}}} s_i(t), \]
where \( s_i(t) \) are uncorrelated purely wide-sense cyclostationary.
- Wide-sense cyclostationarity:
  - \( \mu_s(t) \) and \( R_s(\tau) \) are periodic with period \( T_0 \).
  - Cyclic autocorrelation functions (Fourier coefficients of \( R_s(\tau) \)):
    \[ R_s^\alpha(\tau) = \frac{1}{T_0} \int_{-\infty}^{\infty} R_s(\tau)e^{-j2\pi \alpha \tau} d\tau. \]
- Cyclic spectrum:
  \[ S_s^\alpha(f) = \int_{-\infty}^{\infty} R_s^\alpha(\tau)e^{-j2\pi \alpha \tau} d\tau. \]
- Alternative interpretation:
  - Cross-spectral density of two frequency-shift versions of \( s(x) \):
    \[ S_s^\alpha(f) = S_{ss}^\alpha(f) = \mathbb{E}\{X(f + \frac{\alpha}{2})X^*(f - \frac{\alpha}{2})\}. \]
- Cyclostationary detectors exploits signals cyclic correlation.

Sub-Nyquist Sampling - MWC

- Modulated Wideband Converter (MWC)
- Input Signal: multiband model \( x(t) \) with Nyquist rate \( f_{\text{Nyq}} \) composed of \( 2N_{\text{sig}} \) bands each with max. bandwidth \( B \).
- Analog front-end: composed of \( M \) parallel channels which alias the spectrum, so that each band appears in baseband.
- Signal reconstruction from sub-Nyquist samples
- Energy detection
- Hardware implementation

Cyclostationary Detection from Sub-Nyquist Samples for Cognitive Radios: Between Sparsity and Scarcity

- Nyquist sampling is not an option! ⇒ Sub-Nyquist sampling
- Perform spectrum sensing task efficiently, in spectrum "holes" to unlicensed users
- Comparison of energy detection and cyclostationary detection performance
- Minimal sampling rate for signal reconstruction: \( 2NB \) (twice Landau rate)

Energy Detection in Low SNRs

- Input: one signal with bandwidth: \( 120\text{MHz} \)
- Sampling rates: Nyquist 10GHz - Sub-Nyquist 256MHz
- Dramatic decrease in performance!
- Can we adapt our sub-Nyquist hardware with more robust detection?

Cognitive Radios: Between Sparsity and Scarcity

- Address the conflict between spectrum saturation and underutilization
- Grant opportunistic and non-interfering access to spectrum "holes" to unlicensed users
- Perform spectrum sensing task efficiently, in real-time and reliably

Cyclostationarity

- Process whose statistical characteristics vary periodically with time
- Cyclic spectrum exhibits spectral peaks at certain frequency locations
- Active spectral bands can be retrieved from performing detection on the cyclic spectrum

Reference