Cyclostationary detectors for RFI mitigation

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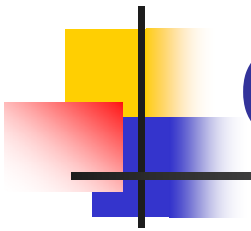

Contents

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Cyclostationarity Definition

- Specific class of non stationary signals:
  - Stationary signals → Invariant statistics in time
  - Non stationary signals → Time-varying statistics
  - Cyclostationary signals → Periodically time-varying statistics

Cyclostationarity Autocorrelation function

- Periodic autocorrelation function

$$R(t+T,\tau) = R(t, \tau)$$

- Fourier series decomposition:

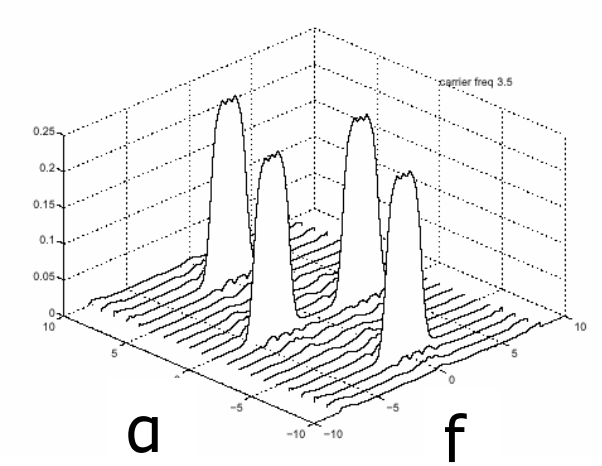
$$R\ (t,\tau)\ = \sum_{\alpha} R\ (\alpha,\tau).e^{i2\pi\alpha t}$$

where α is the cyclic frequency

- $R_x(\alpha,\tau)$ is the cyclic autocorrelation function

Cyclostationarity
Cyclic spectrum

- Cyclic spectrum:
  - Cyclic Wiener relation: $S_x(\alpha,f) = TF[R_x(\alpha,\tau)]$
  - Null for stationary signals when $\alpha \neq 0$



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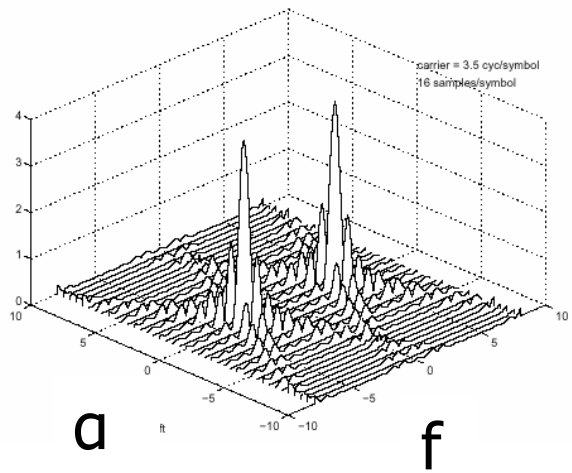
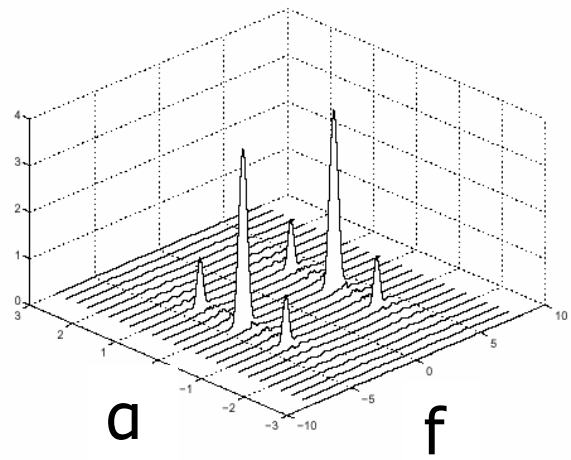


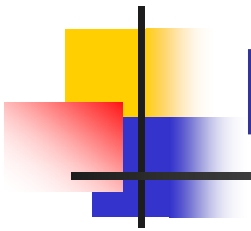
QPSK



Filtered QPSK

Cyclostationary detectors for blanking

- Detection of cyclostationary signals
  - Hidden periodicity → Energy for $\alpha \neq 0$
- *a priori* knowledge:
  - Cyclic frequency α_c
- Constraint
  - Real Time



Principle

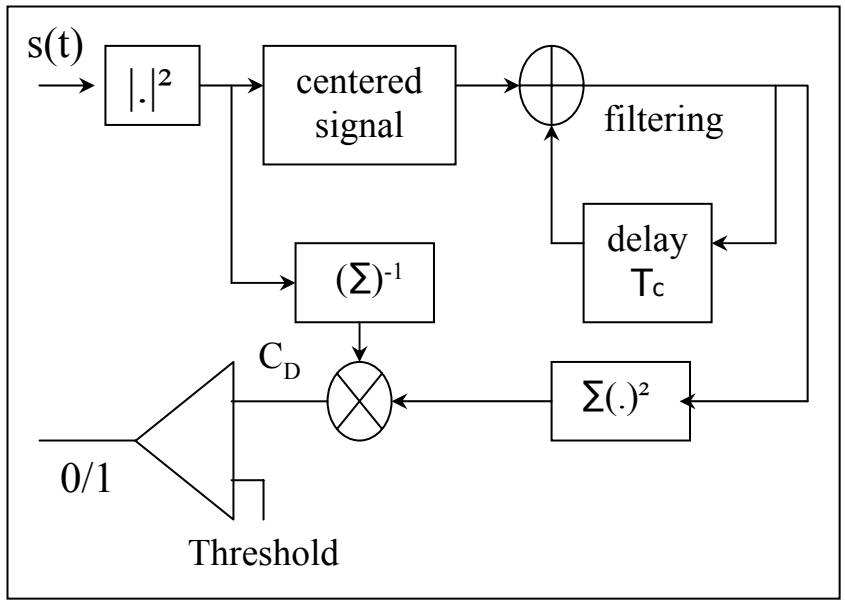
- Transform in a periodic signal
  - Straightforward transformation: $|.|^2$
  - Corresponding to the FX receivers
- Detect the hidden periodicity
  - 2 methods : Cyclodet
    IndiCyclo
  - Time domain approach

Cyclodet

- Synchronized averaging
  - Corresponding to a comb filter
  - Constraint on the cyclic period

    ↳T_c is an integer

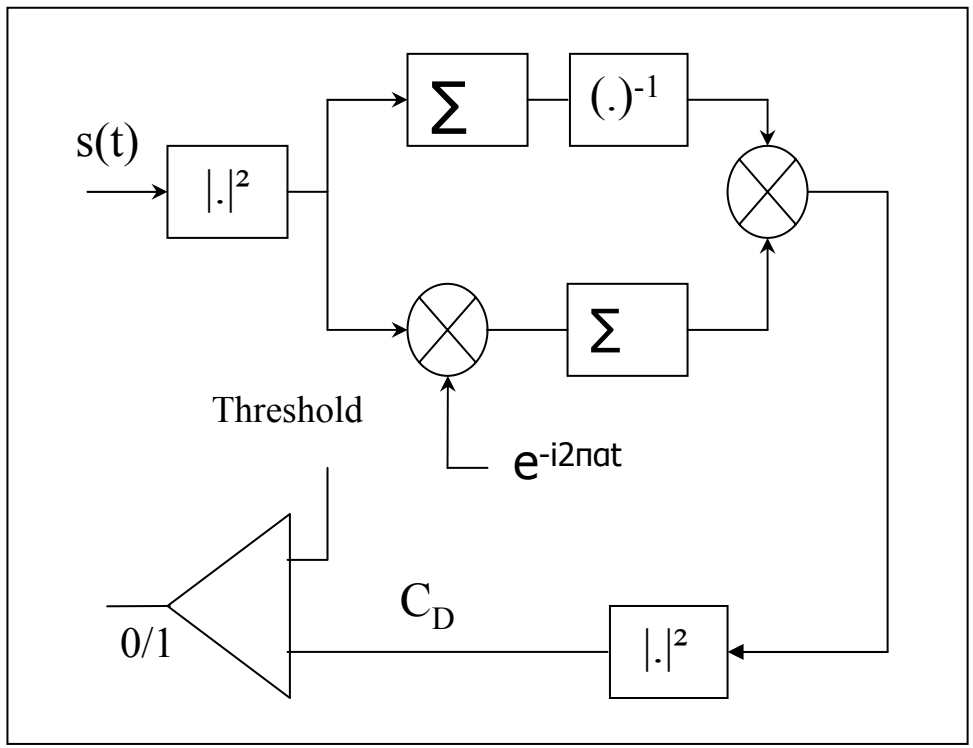
$$C_D = \frac{\sum_t \left| H_{T_c} \otimes |s(t)|^2 \right|^2}{\sum_t |s(t)|^2}$$



IndiCyclo

- Same idea but with a different filter
  - No constraint on the cyclic period T_c

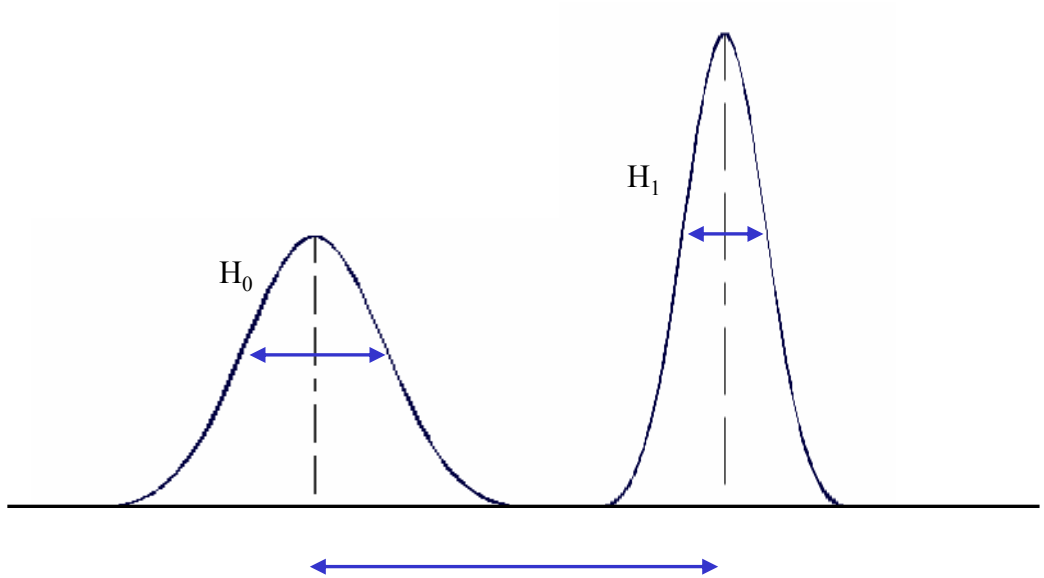
$$C_D = \frac{\left|R_s(\alpha_c, 0)\right|^2}{\left|R_s(0)\right|^2} = \frac{\left|\sum_t |x(t)|^2 . e^{-i2\pi\alpha_c t}\right|^2}{\sum_t |x(t)|^2}$$



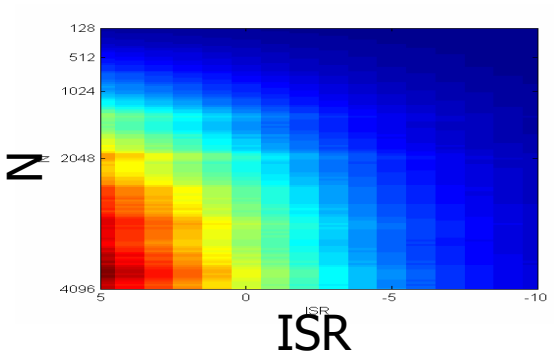
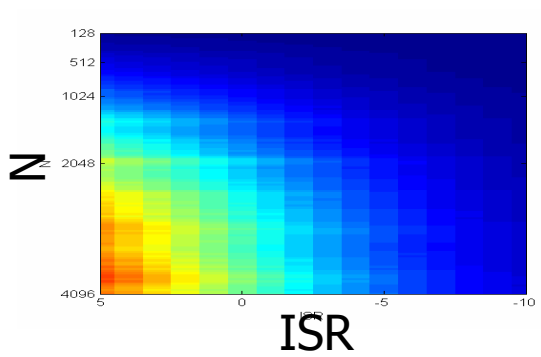
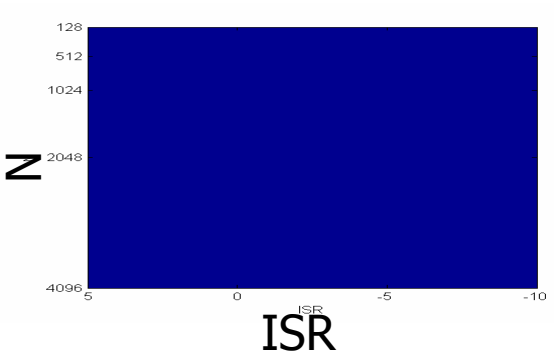
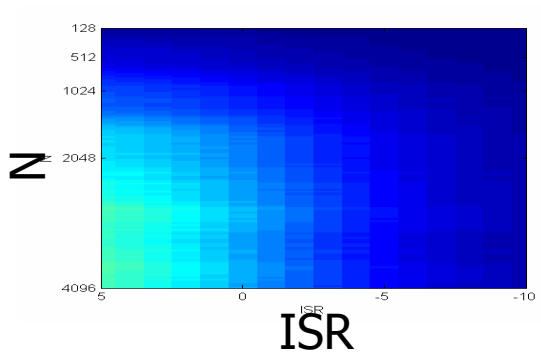
Comparison of the 2 methods

- Comparison based on the Fisher criterion

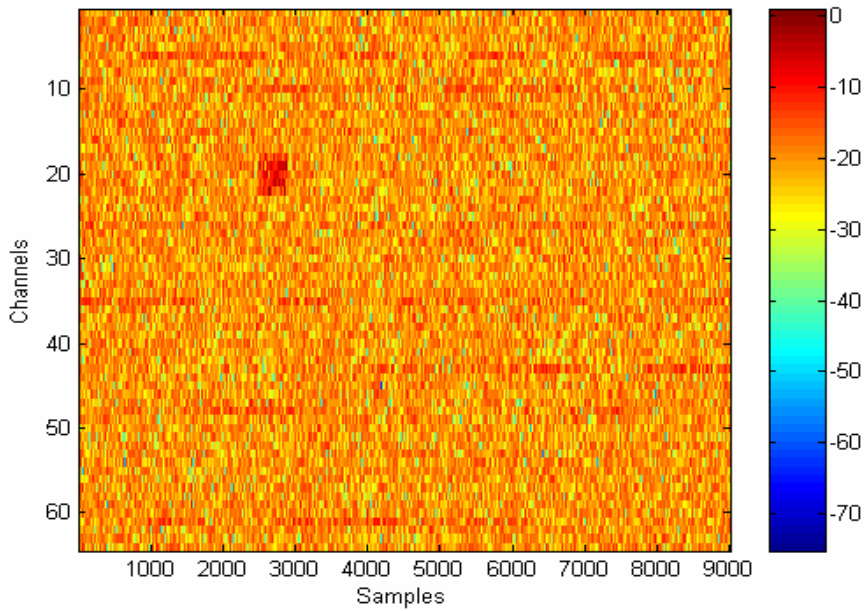
$$C_F = \frac{(E_{H1}[C_D] - E_{H0}[C_D])^2}{Var_{H1}[C_D] + Var_{H0}[C_D]}$$

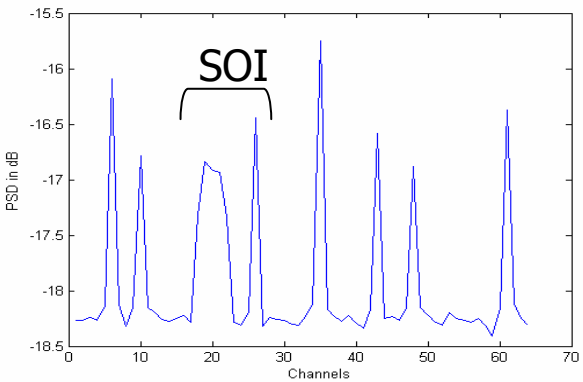


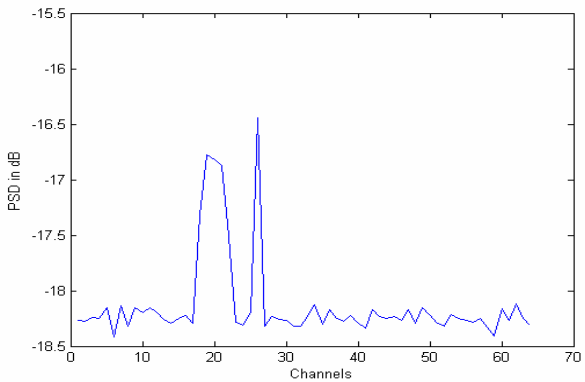
Comparison – Results

	Cyclodet	IndiCyclo
T_c is an integer		
T_c is not an integer		

Blanking Simulation

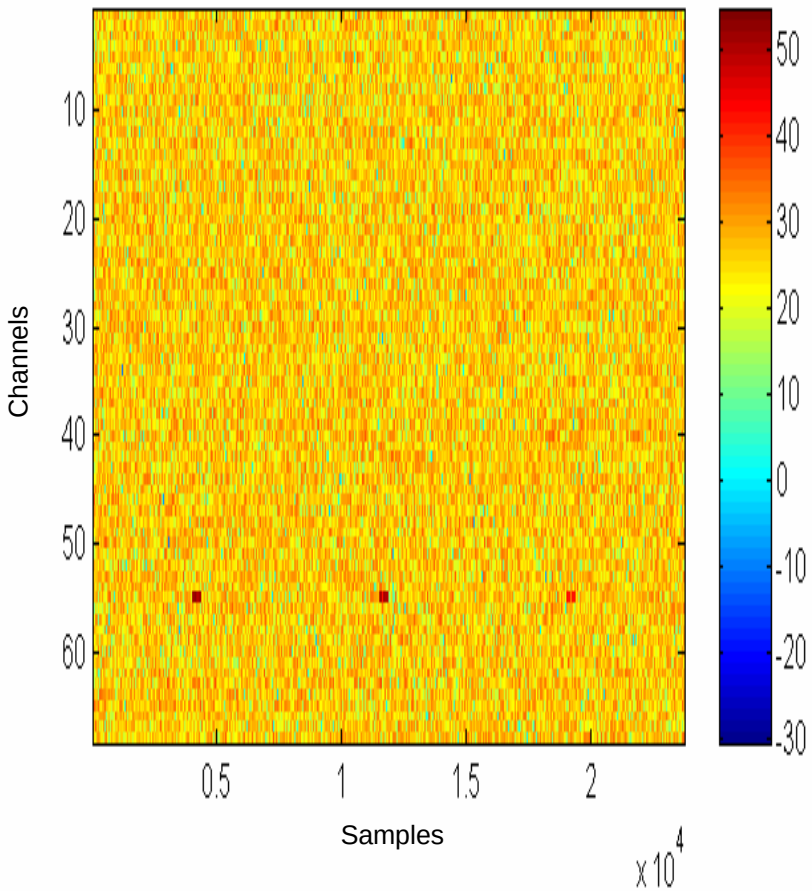


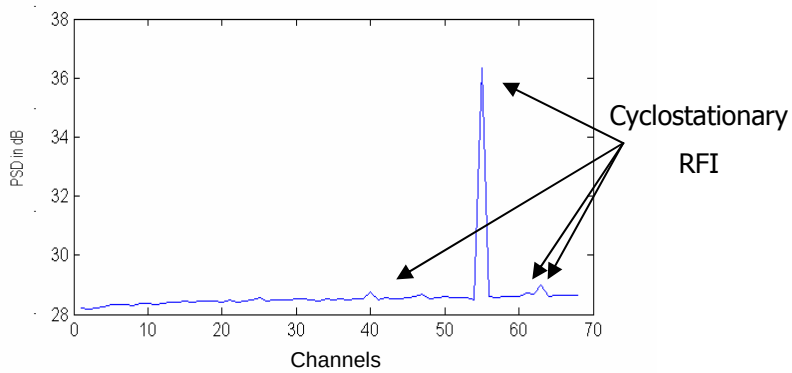


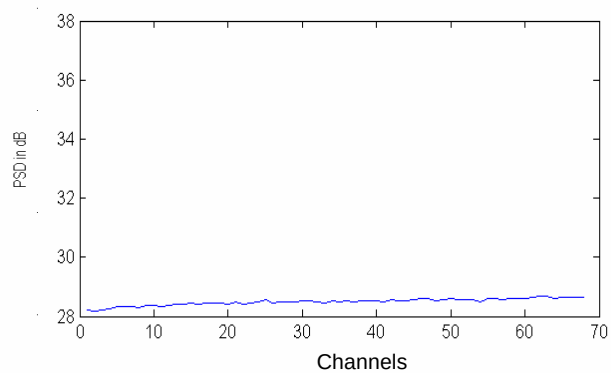


Local ISR = - 5 dB and N= 512 samples
Tc is not an integer.
False alarm rate: 5.6 %
Non detection rate: 0.0%

Blanking
Real data







Rejected data rate:
0.89 %

Conclusion

- Simulations and real data: encouraging results with low N and ISR
- Frequency resolution
- Next step: implementation
- www.obs-nancay.fr/rfi