BicoMon

Steve Penn (HWS) & Vijay Chickarmane (LSU)

What are Higher Order Statistics?

- 1D Statistics:

  » Correlation: $C_{xy}(t) = \int_{-\infty}^{\infty} x(\tau) \, y(t + \tau) \, d\tau \iff X(f) \, Y^*(f) = S_{xy}(f)$

  » Power Spectral Density: $C_{2x}(t) \iff X(f) \, X^*(f) = S_{2x}(f)$

  » Coherence: $C_{xy}(f) = \dfrac{S_{xy}(f)}{\sqrt{S_{2x}(f) \, S_{2y}(f)}}$

    – Tells us power and phase coherence at a given frequency

Second Order Statistics

- **2D Statistics:**
  - » Bicumulant:

$$C_{xyz}(t,t') = \int_{-\infty}^{\infty} x(\tau)\, y(t+\tau)\, z(t'+\tau)\, d\tau \iff X(f_1)\, Y(f_2)\, Z^*(f_1+f_2) = S_{xyz}(f_1, f_2)$$

  - » Bispectral Density:

$$C_{3x}(t) \iff X(f_1)\, X(f_2)\, X^*(f_1+f_2) = S_{3x}(f_1, f_2)$$

  - » Bicoherence:

$$\mathsf{C}_{xyz}(f) = \frac{S_{xyz}(f_1, f_2)}{\sqrt{S_{2x}(f_1)\, S_{2y}(f_2)\, S_{2z}(f_1, f_2)}}$$

    - Tells us power and phase coherence at a coupled frequency

Why Higher Order Statistics?

- For a Gaussian process: $C_{nx}(t) = 0,$ for $n > 2$

- For independent processes:

$$z(t) = x(t) + y(t), \quad C_{nz}(t) = C_{nx}(t) + C_{ny}(t) \xrightarrow{\ n>2\ } C_{ny}(t)$$

- Allows for separation of Gaussian process for n>2
  - » Visual check of frequency coupling and phase noise
  - » Statistical test for the probability of gaussianity and linearity
  - » Iterative process to reconstruct nongaussian signal from the higher order cumulants

Monitor Plan - MatLab tool

- ● MatLab tool:
  - » Flexible tool for quickly examining auto-bicoherence
  - » Allows one to see evidence of bilinear couplings
  - » Exists!
  - » Does not allow continual monitoring.
  - » Does not allow full diagnosis of problem (no cross-bicoherence)
  - » Vijay will continue development for upcoming E runs, S3.
  - » Gaby will discuss result in next talk.

Monitor Plan - Foreground Monitor

- Plots (cross-)bicoherence, (cross-)bispectrum, & PSD's

- Automatic decimation

- Optimized windowing

- User specified:
  - » f_{max} & Δf (Limited to factor 2^n)
  - » accuracy/averaging
  - » Calculation method

- Outputs GIF files of the plots

- Vectorized FFT routines for speed

- Heterodyning

- Monitoring BC of certain ROI and changes in BC

- Output of ROI to Background Monitor

- Not done

Monitor Plan - Background Monitor

- Monitors integrated BC in ROI

- Monitors changes in BC in ROI

- Monitors integrated BC over unique area (Gaussianity)

- Underdevelopment for mini-Eruns