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QUASI COHERENT OVERLAPPING METHOD

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Motivation

Interpolated DFT and single-model sine fit algorithms have relatively high estimation bias when the sampled signal has harmonic components present and the signal is sampled non-coherently. This is especially evident when low number of signal periods are sampled, e.g. the signal and its harmonic frequency bins are not strongly separated.
However, in most, but not all estimation algorithms, this bias is not present when the signal is sampled coherently. Using this property, the new quasi coherent overlapping method is proposed, which provides a reduction of estimation errors due to harmonics when the signal is actually sampled non-coherently.

Discussions

- Procedure is general and works for all DFT based algorithms, PSFE, and others.
- Procedure does not work for algorithms which are sensitive to harmonics in the coherent sampling case (like Four Parameter Sine Fit algorithm).
- Procedure is easy to implement and does not involve any modification of the given algorithm.
- The processing time penalty is approximately a factor of 2.
- The noise sensitivity is not increased.

References

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2) “IEEE Standard for Digitizing Waveform Recorders”, IEEE Std 1057-2007, April 2008
3) K. Duda, Interpolation Algorithms of DFT for Parameters Estimation of Sinusoidal and Damped Sinusoidal Signals, Fourier Transform – Signal Processing, S. M. Salih, Ed.: InTech, 2012
4) R. Lapuh, “Estimating the Fundamental Component of Harmonically Distorted Signals From Noncoherently Sampled Data,” IEEE Trans. Instrum. Meas., vol. 64, no. 6, June 2015

The improved procedure

For most algorithms, harmonic distortion will not interfere signal parameter estimation for the coherent case. This fact is used in the proposed improved procedure.

Step 1.

Estimate signal frequency (f_e) from the sampled record with a given algorithm, using all samples available (N).

Step 2.

Define two overlapped equal length (N_T) windows W1 and W2, based on the estimated frequency f_e and sampling time T_S, so that data in each window corresponds to the smallest deviation from the coherent sampling case.
The following expression is minimized:

$$\min_{N_T} \frac{||N_T f_e T_S||}{N_T f_e T_S - 1}; \quad N/2 \le N_T \le N$$

Step 3.

Perform signal estimation on both windowed data W1 and W2. The resulting parameter estimate is the average value of both windowed results.

Results

- Strongly reduced errors due to harmonic distortion
- Effective for most algorithms
- Does not require any algorithm modification
- No noise performance degradation
- Modest speed performance degradation (x 2)

- Does not work for 4PSF algorithm

Results

THD = 1 % / N = 1000