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UNCERTAINTY OF THE SIGNAL PARAMETER ESTIMATION FROM SAMPLED DATA

Authors: Rado Lapuh, Martin Šíra, Matjaž Lindič and Boštjan Voljč

Motivation

This work presents the evaluation of uncertainty components attributed to the algorithm used to estimate sampled signal parameters. The white noise in the signal will influence the **standard deviation** of the estimates while signal imperfections like harmonic distortions, interharmonics and even non-white noise would produce **bias**, leading to non-statistical uncertainties.

Estimation uncertainty components

An a-priori knowledge of sampled signal is required to account for proper evaluation of these uncertainties.

$$U(e) = \sqrt{B^2(e) + \sigma^2(e)}$$

$B(e)$ ... estimator bias
$\sigma(e)$ ... estimator standard dev.

$$\sigma_{CRLB}(\varphi) \cong \sigma_n \sqrt{\frac{8}{N}}$$

$\sigma_{CRLB}(\phi)$ ... Cramer-Rao lower bound standard dev.
σ_n ... signal noise standard dev.

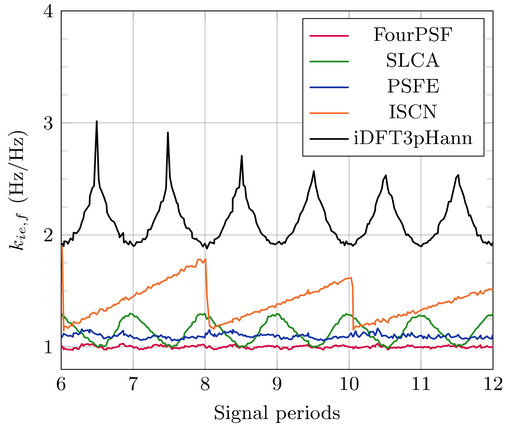
$$k_{ie}(e) = \frac{\sigma(e)}{\sigma_{CRLB}(e)}$$

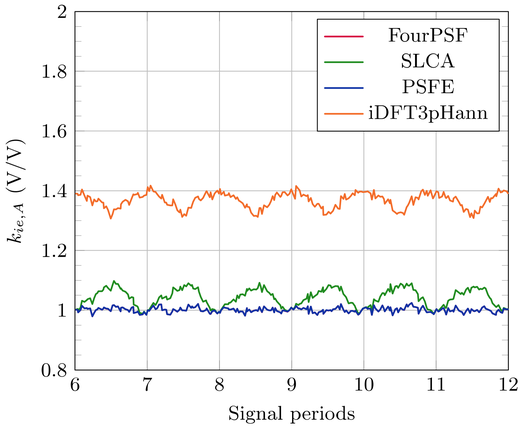
$k_{ie}(\phi)$ ... inefficiency coefficient

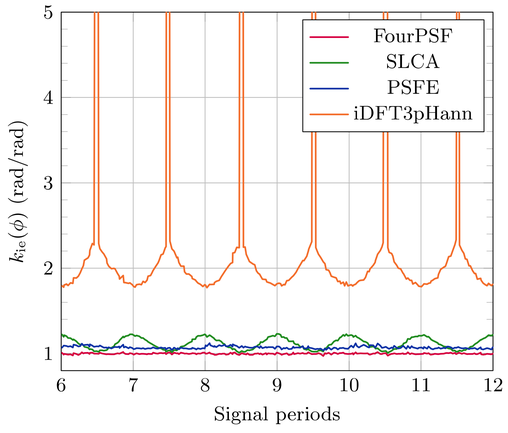
Discussions

- Efficient algorithms have lowest standard deviation (CRLB), others can amplify noise even a few times.
- Window base algorithms have generally poor inefficiency (> 1).
- Algorithms noise performance shall be tested over noise levels and number of signal periods.
- Algorithms shall be tested for harmonic components present in the signal (not shown here).
- Algorithms are largely biased by a presence of interharmonics.
- Window based algorithms are normally dealing well with interharmonics.

Estimator inefficiency







FourPSF: Four parameter sine fit algorithm

SLCA: Spectrum fitting algorithm

PSFE: Phase sensitive frequency estimator

ISCN: Interpolation and scanning algorithm

iDFT3pHann: Three point interpolated DFT algorithm using Hann window

N = 1000
f = 52.3 Hz
T_S = 1 ms
R = 10000

Estimator susceptibility to 1 % interharmonic component