High accuracy signal parameter estimation algorithm for calibration of PMU devices

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Introduction

PMU - Phasor Measurement Unit is a device that synchronously samples an electrical waves on an electricity grid and accurately determines amplitude, frequency and phase. Calibration of these devices provides certainty and quality of the power system.

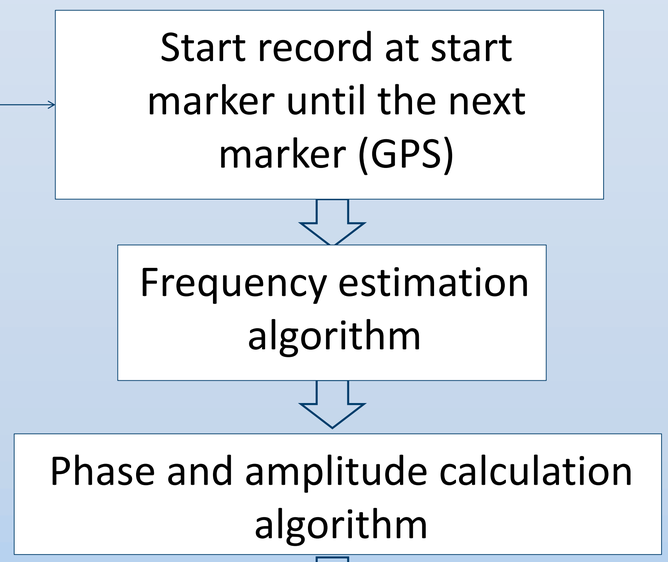
Goals

- Generate reference waveform in MATLAB of which PMU parameters are known
- Sample generated waveform and calculate PMU parameters using different algorithms
- Analyze simulation results and propose algorithm with better accuracy for calibration of PMU devices

About proposed algorithm

Proposed algorithm works as follows:

- Recording input data and separating it into windows (separation is realized using time stamp, in real systems GPS is used). By selecting window separation to be an integer number of periods, a high attenuation of interfering harmonic components is achieved.
- Estimation of waveform fundamental frequency using improved phase sensitive frequency estimation algorithm
- Phase and amplitude calculation using separate algorithm
- Results are saved including a time stamp



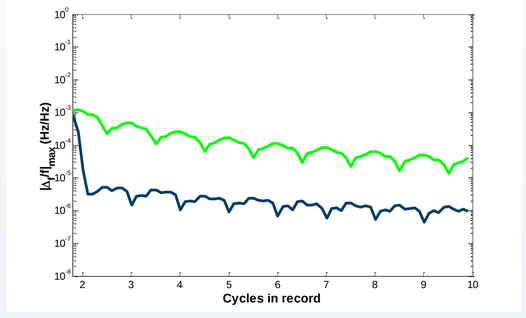
Relative frequency error of proposed algorithm

The following graph shows comparison between Standard four parameter sine fit and proposed algorithm of maximum relative frequency error as a function of signal cycles in the record.

- Proposed algorithm shows a dramatic improvement at more than 2 cycles in the record by keeping maximum relative estimated frequency error below 5×10^{-6}.

Benefits of proposed algorithm

- High attenuation of interfering harmonic components
- Very fast performance
- Accuracy

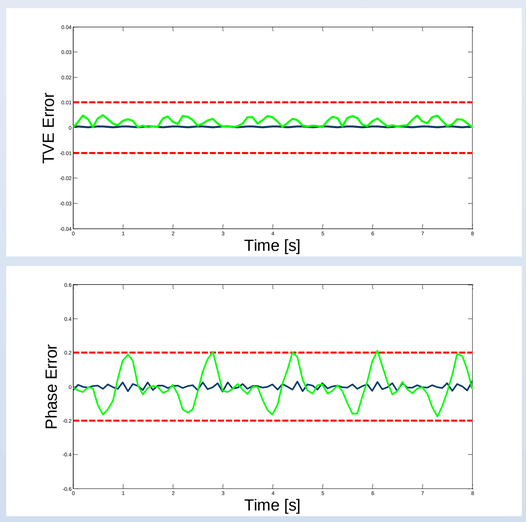


Waveform parameters: N samples=1000, Amplitude of second harmonic=0.01·A1, SNR=120 dB, f=52,1 Hz

Results of simulations

- TVE (Total Vector Error)
- Phase error
- ROCOF (Rate Of Change Of Frequency) error

Limits were set according to IEEE Std C37.118TM - 2005.



Legend:

Standard four parameter sine fit algorithm ——

Proposed algorithm ——

Limits -------

Waveform parameters:

- Fundamental frequency: *f*=50,3 Hz
- Harmonics [1, 2, 3, 4], magnitudes [230, 57, 45, 23] V, phases [45, 16, 32, 165] °
- Interharmonic: *f*=274 Hz, magnitude=10 V, phase 86°

Conclusion

- Proposed algorithm is more accurate for calculation of PMU parameters for highly harmonically distorted signals
- Proposed algorithm works faster than Standard four parameter sine fit algorithm
- Proposed algorithm is thereafter more appropriate for calibration purposes

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