Computationally Efficient Synchrophasor Algorithms for Ultra-High-Rate Phasor Measurements

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1500 Hz Real-Time Synchrophasor Measurement

Motivation:

1. Low-cost is critical for application of synchronized measurements on distribution system. Computationally efficient and accurate measurement algorithm is one of key components for low-cost target.

2. 60 measurements/second can not capture the grid events that occur at cycle level such as sub-synchronous oscillation, system transient faults, etc.

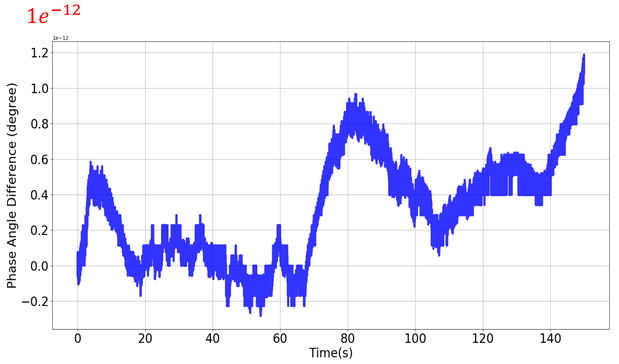
State-of-the-Art: 60 Hz (or 120 Hz) Synchrophasor measurements in PMUs.

Our capability: 1500 Hz Synchrophasor measurements on low-cost hardware.

Application Examples:

- ✓Synchrophasors measurements on low-cost hardware
- ✓high frequency transient events capture
- ✓Accurate oscillation source localization
- ✓Fast grid control and protections (e.g., high/low frequency tripping)
- ✓High-precision Rate of Change of Frequency estimation

Phase Angle Estimations



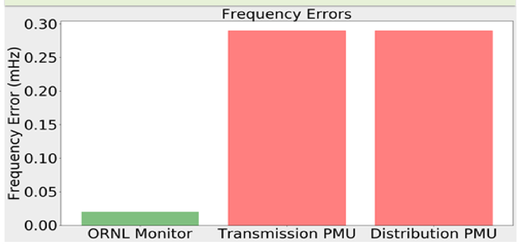
Same Accuracy as Classical DFT Algo (140 s Field Data)

Sampling Rate	Window Size (cycle)	Computation Time (second)		Faster
		classic	new	
1500 Hz	1	7.23	0.59	12x
	3	18.4	0.57	32x
	6	35.6	0.58	61x

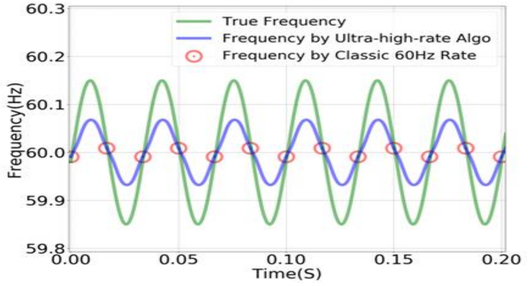
10 - 100x faster vs Classical DFT Algo (140 s Field Data)

Frequency Estimations

Ultra-High-Precision



Extremely Low Errors vs T/D PMUs

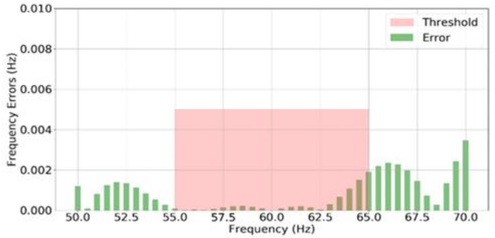


Dynamics Monitoring vs T/D PMUs

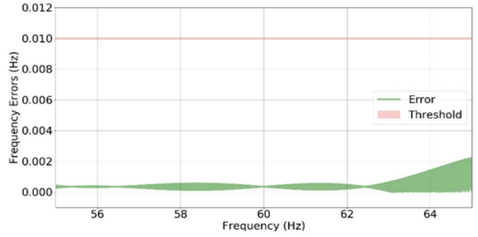
Extremely Low Computation Cost

Sampling Rate	Window Size (cycle)	Computation Time (second)		Faster
		DFT Algorithm	Proposed Algorithm	
1440 Hz	5	1.279	0.002	650x
	10	2.396	0.002	1200x
	20	4.611	0.002	2300x
2880 Hz	5	2.590	0.002	1300x
	10	4.870	0.002	2400x
	20	9.240	0.002	4600x

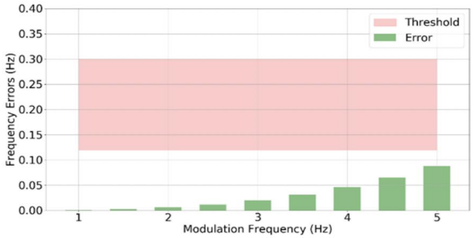
500 - 5000x Faster vs Classical DFT Algo



Frequency Offset Test (vs PMU Std.)



Frequency Ramping Test (vs PMU Std.)



Phase Modulation Test (vs PMU Std.)

Summary

- ✓ Accurate and computationally efficient Synchrophasor measurement algorithm.
- ✓ Contribute to Ubiquitous and low-cost synchrophasor measurements on distribution system.
- ✓ Contribute to dynamic monitoring, modeling, control and protection of DERs.

1500 Hz Synchrophasors on FNET/GridEye Monitor UGA