



Distribution Level Phasor Measurement Accuracy Limits

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Outline

- Introduction
- Methodology
- Error Analysis
- Conclusions

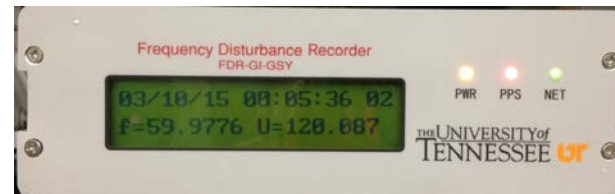
Introduction

- Looking beyond wide area monitoring
- Potential value with more generation and load control at distribution level
- Measurement accuracy and error impact are issues – no standard for distribution level measurements
- Focused on frequency and phase angle



PMU

(Phasor Measurement Unit)

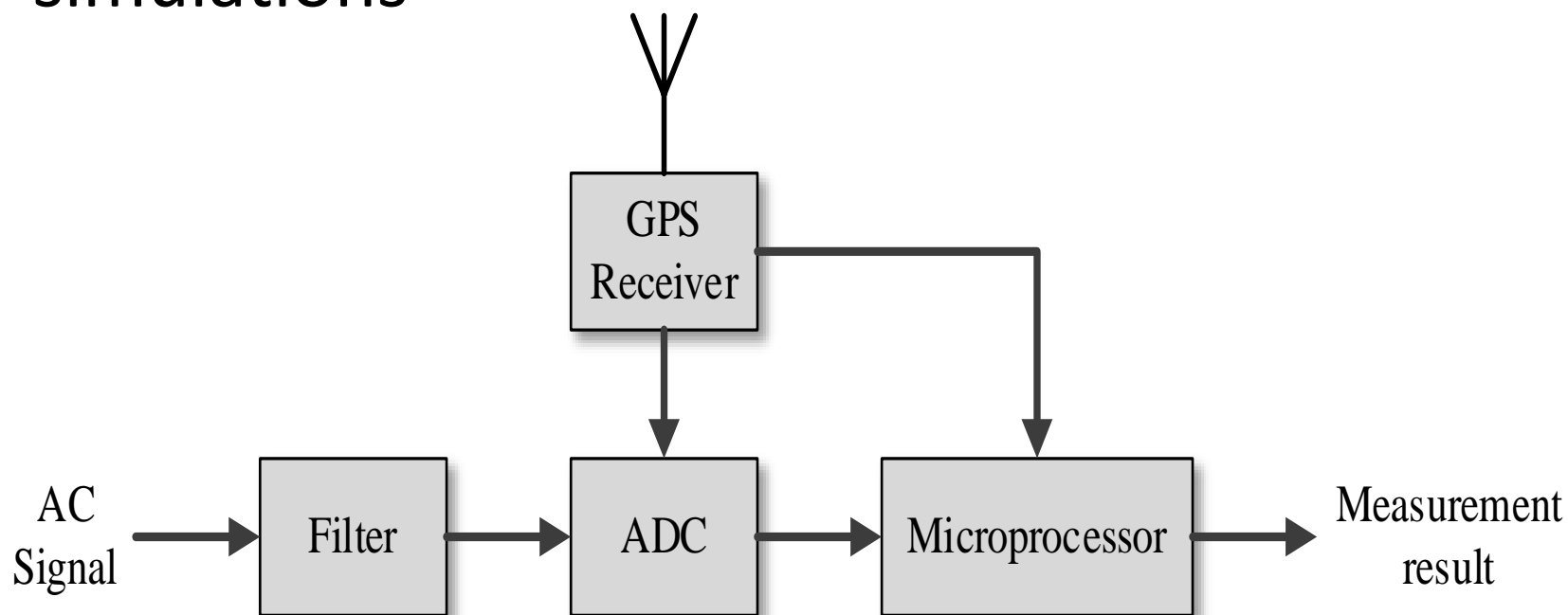


FDR

(Frequency Disturbance Recorder)

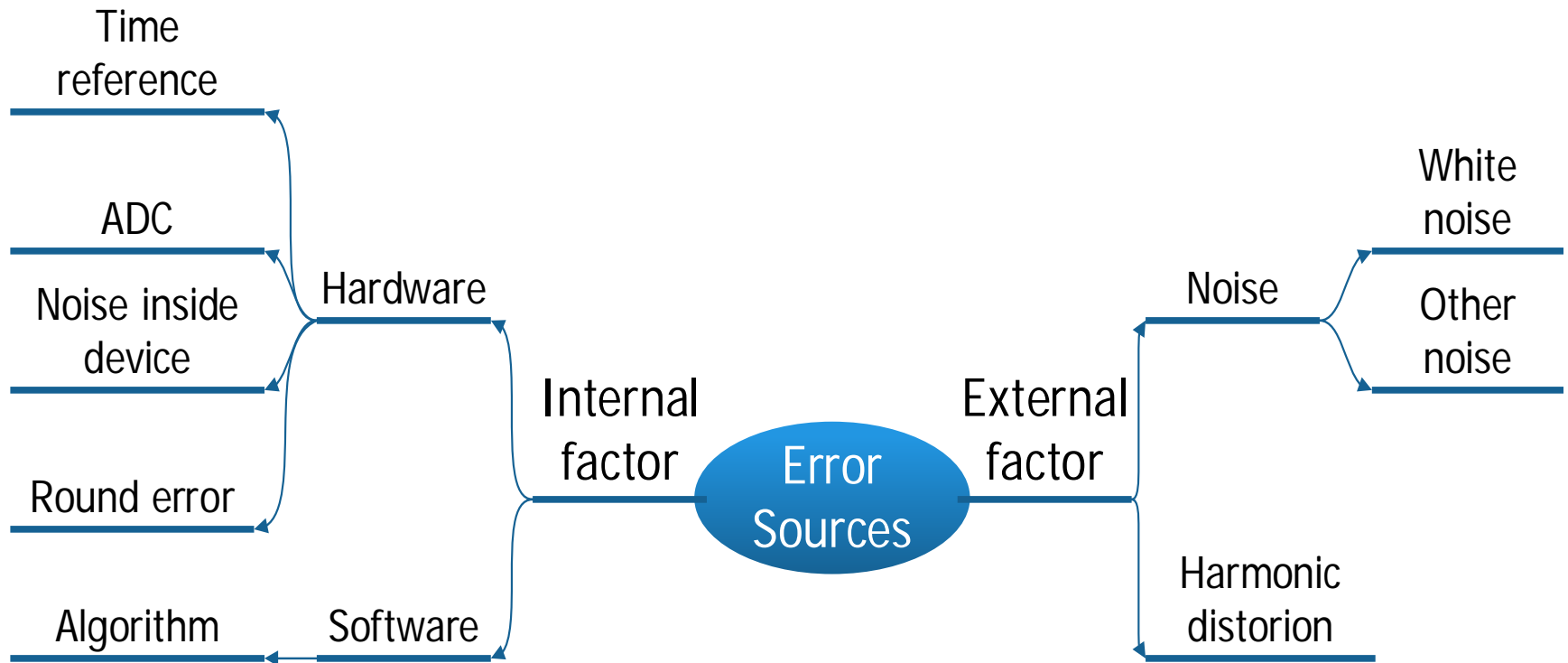
Methodology

- Error calculations were performed based on typical accuracy values, measurements, and simulations



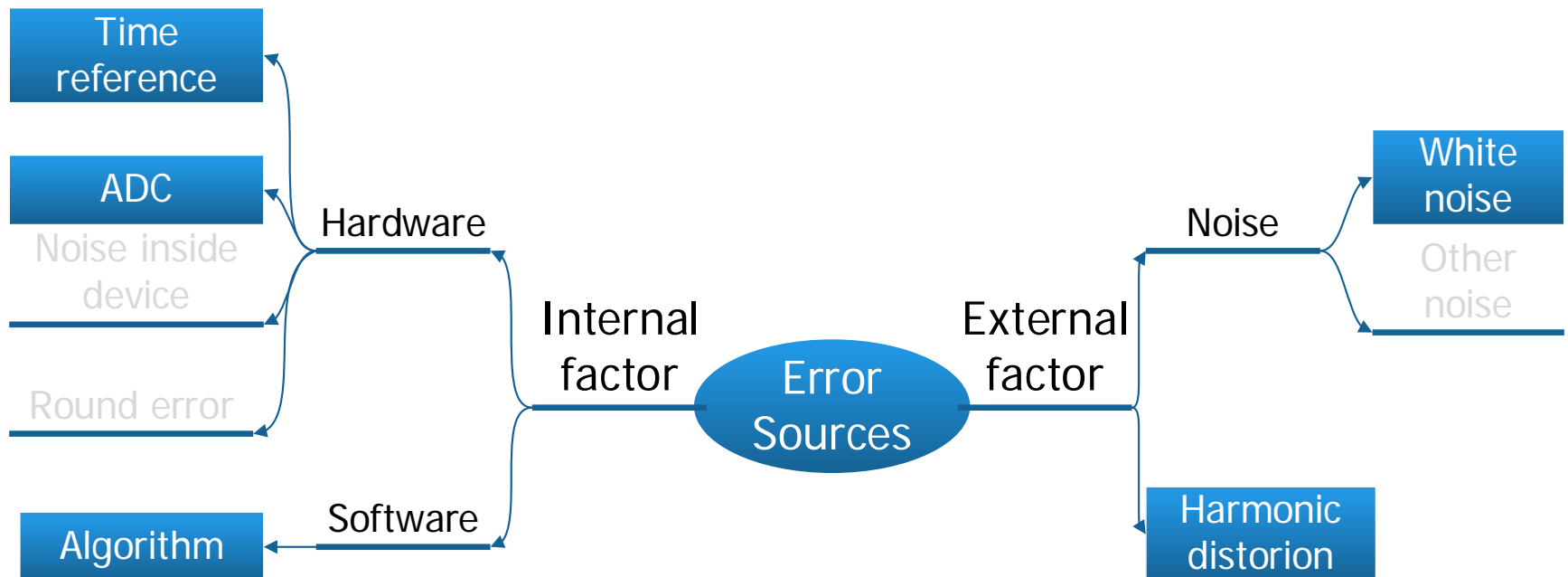
Methodology

- Error sources vary – both internal and external



Methodology

- Our focus was on errors with larger impact



Internal Factors

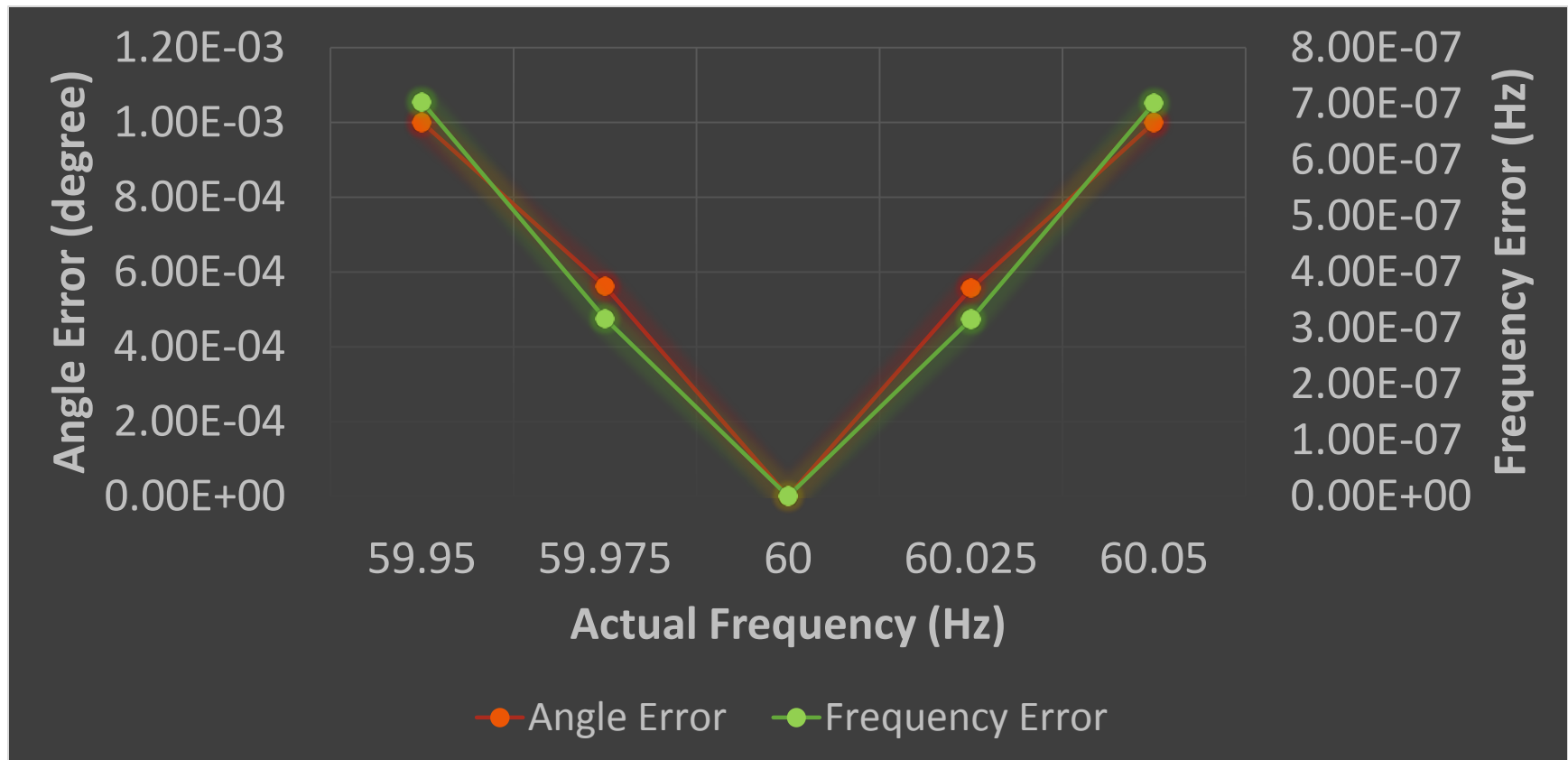
- Main factors
 - Algorithms
 - Time reference
 - ADC
- Approach
 - Calculations based on typical inaccuracies
 - Simulation

Algorithm Error

- Fed digitized sinusoidal signal with known frequency, amplitude, and angle into measurement algorithm
- Measurement algorithm -Discrete Fourier Transform (DFT)
- Error obtained by comparing estimated values and true values
- Increased simulation time (resampling) until max positive and negative error converged

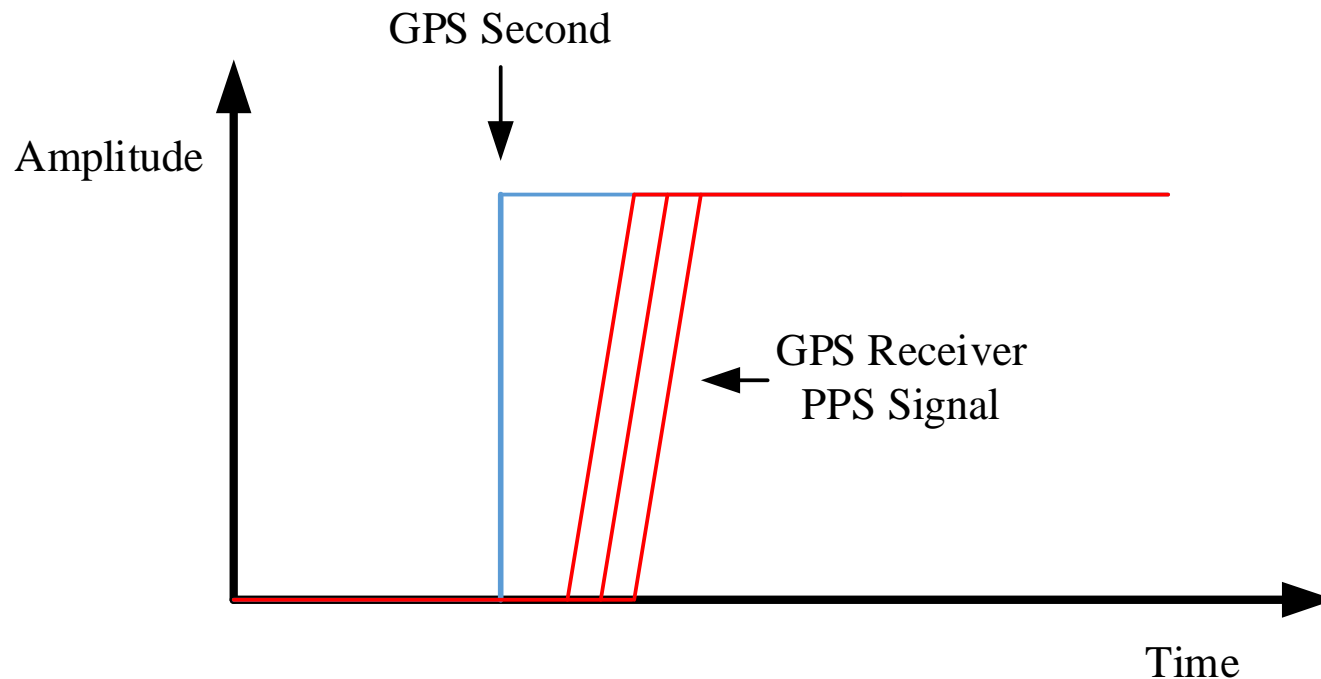
Algorithm Error

- Result - Sensitive to frequency deviation



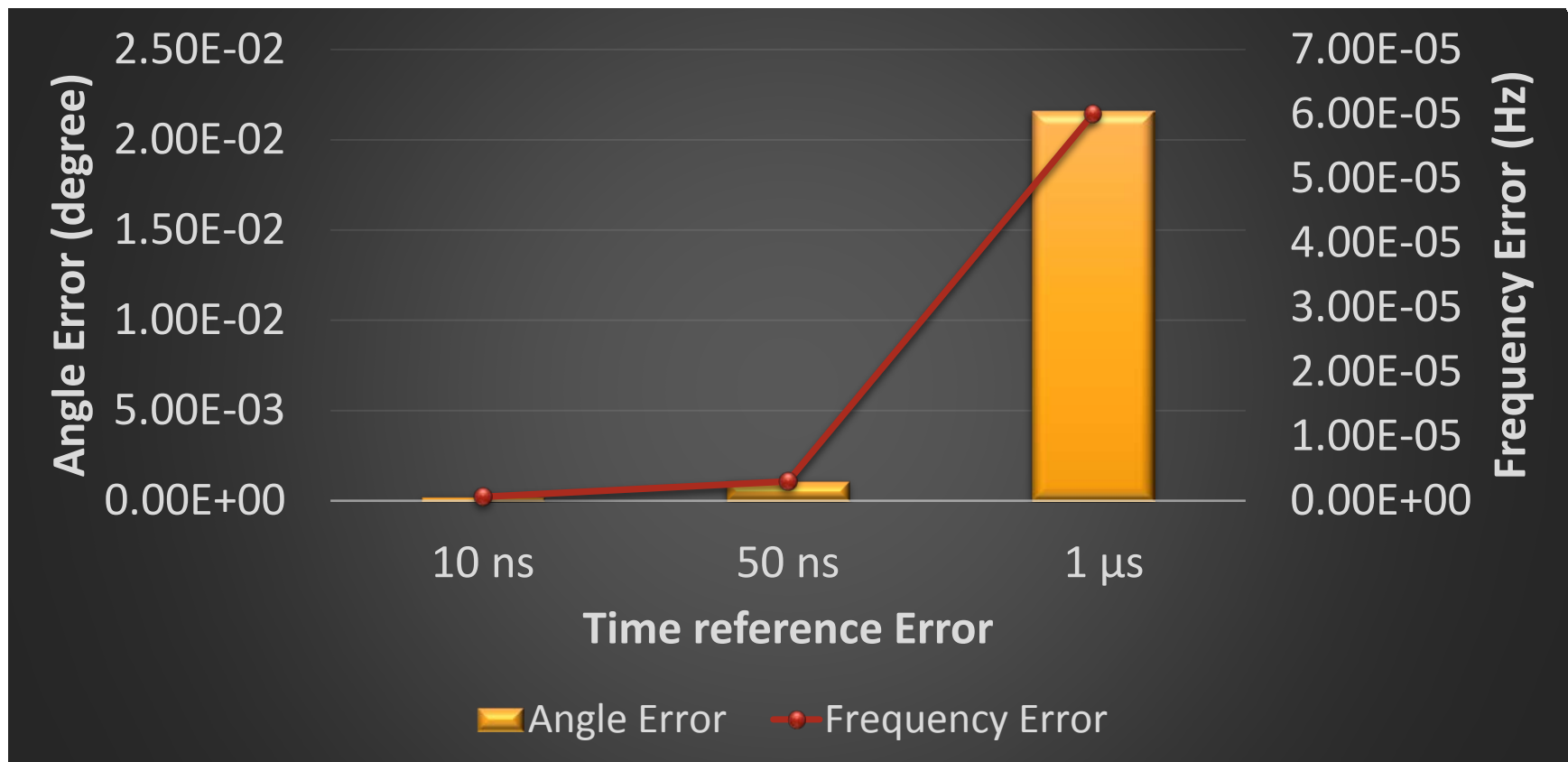
Time Reference Error

- GPS: 1 sec time/frequency reference
- PPS signal: typical jitter - 50 ns to 1 μ s; held to 10 ns with effort



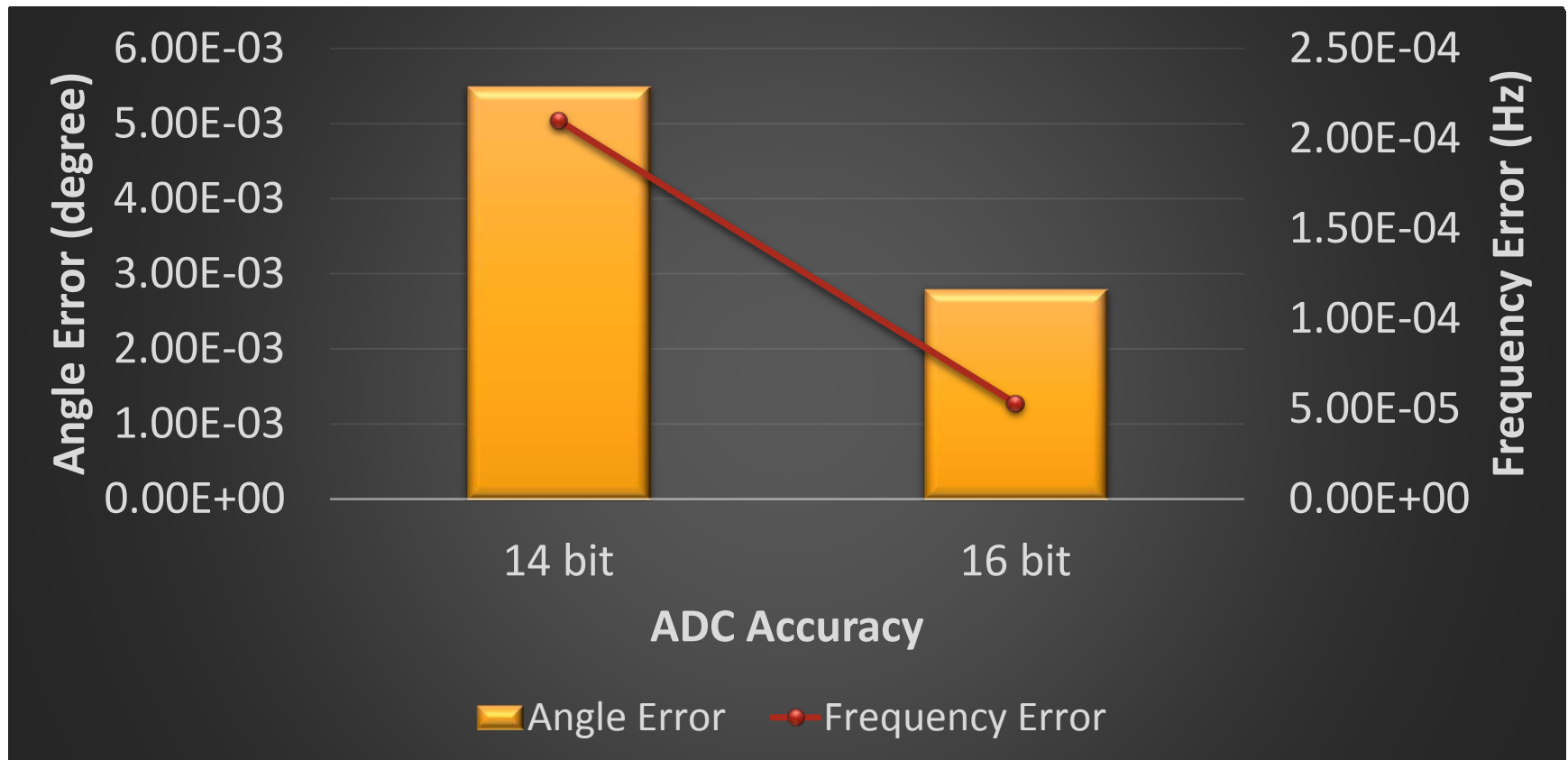
Time Reference Error

- Result ($f = 59.95$ Hz) – jitter matters



ADC Error

- Results ($f = 59.95$ Hz) – better resolution helps
- 1 least significant bit (LSB) error

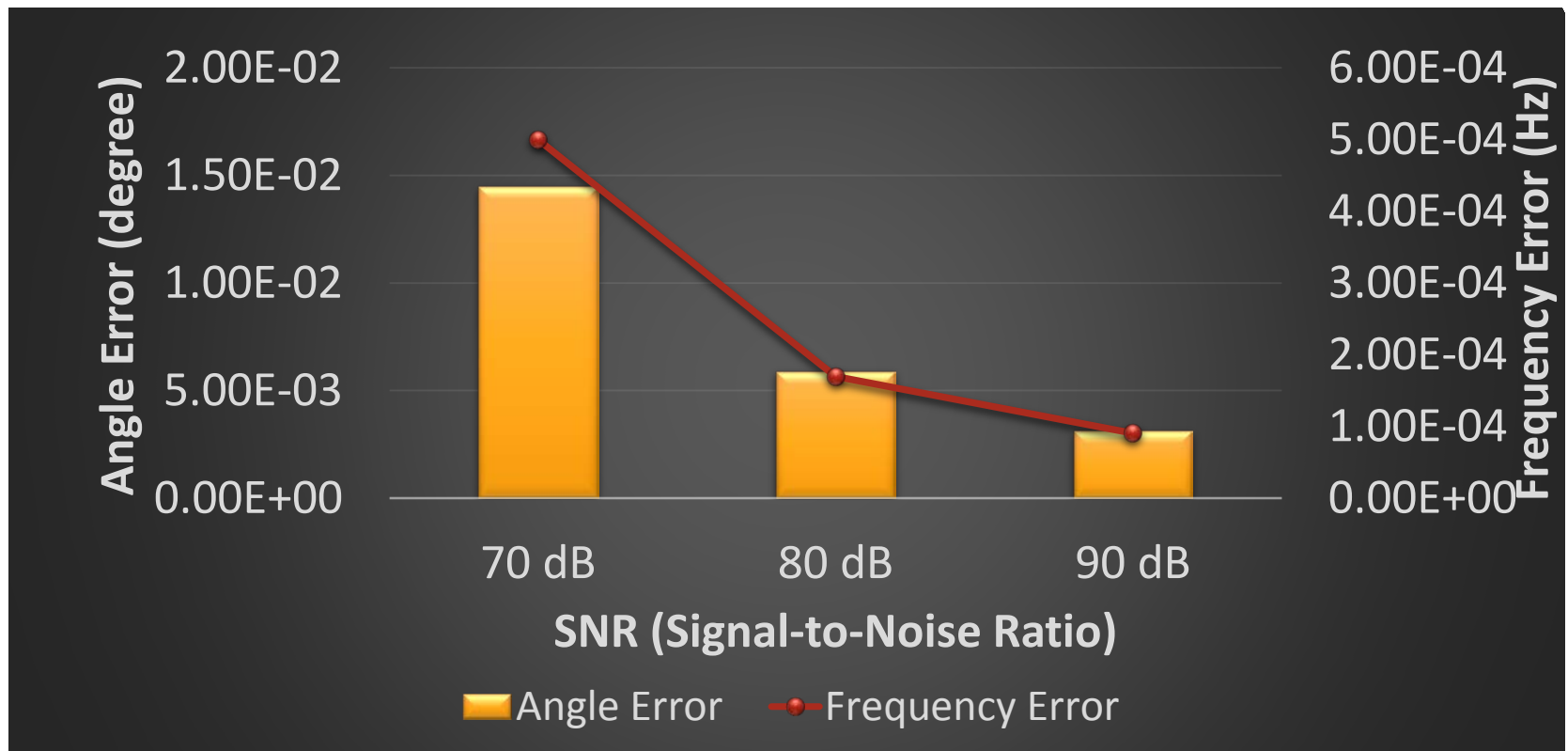


External Factors

- Main factors
 - White noise
 - Harmonic distortion
- Approach
 - Measure the real noise level
 - Simulation
 - $f=59.95$ Hz

White Noise

- Result ($f = 59.95$ Hz) – SNR matters
- Four cases – calculated power spectrum densities



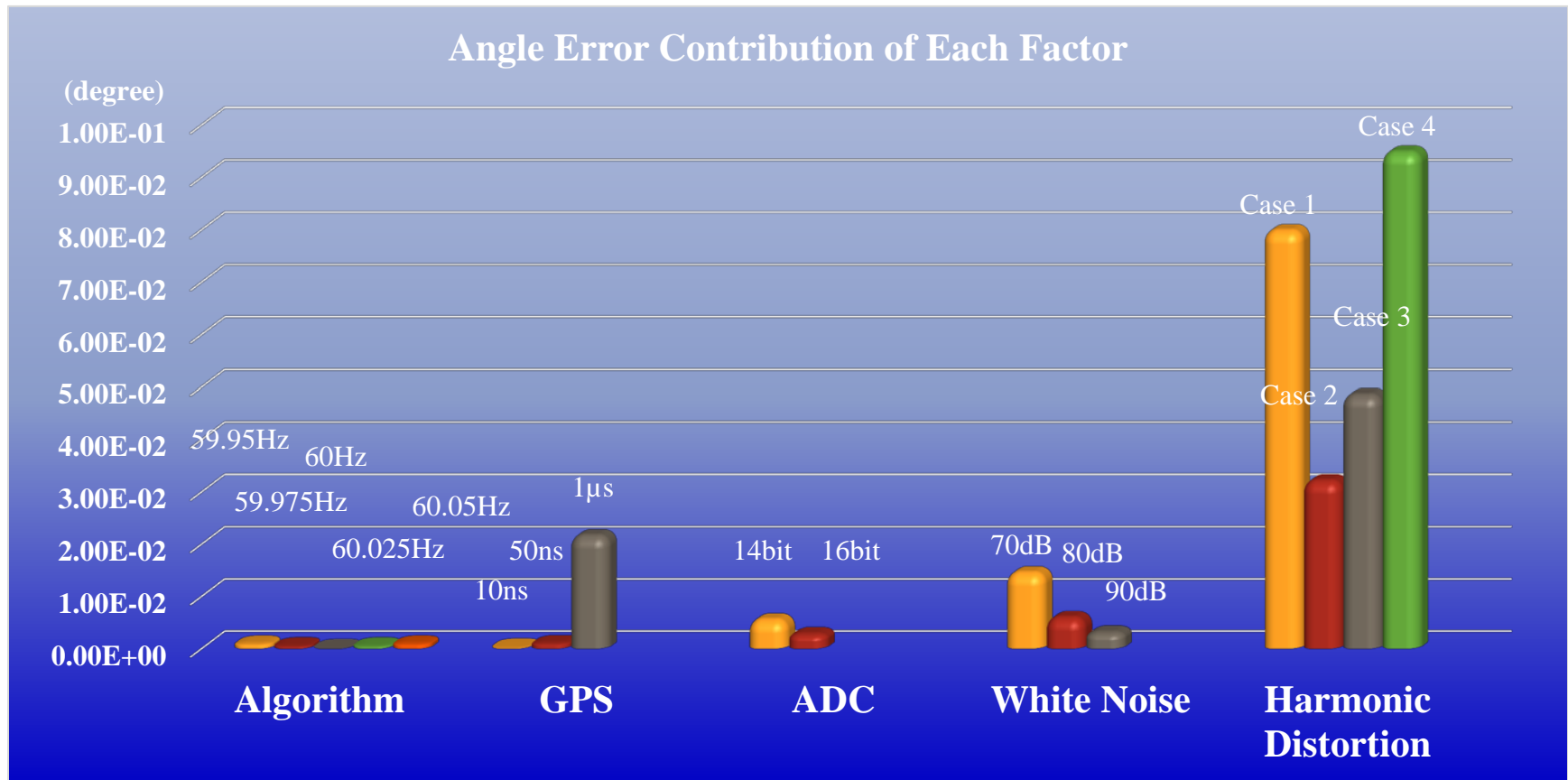
Harmonics Distortion

- 2nd - 25th harmonics from 4 cases, ($f = 59.95$ Hz)
- Higher order components contribute more error



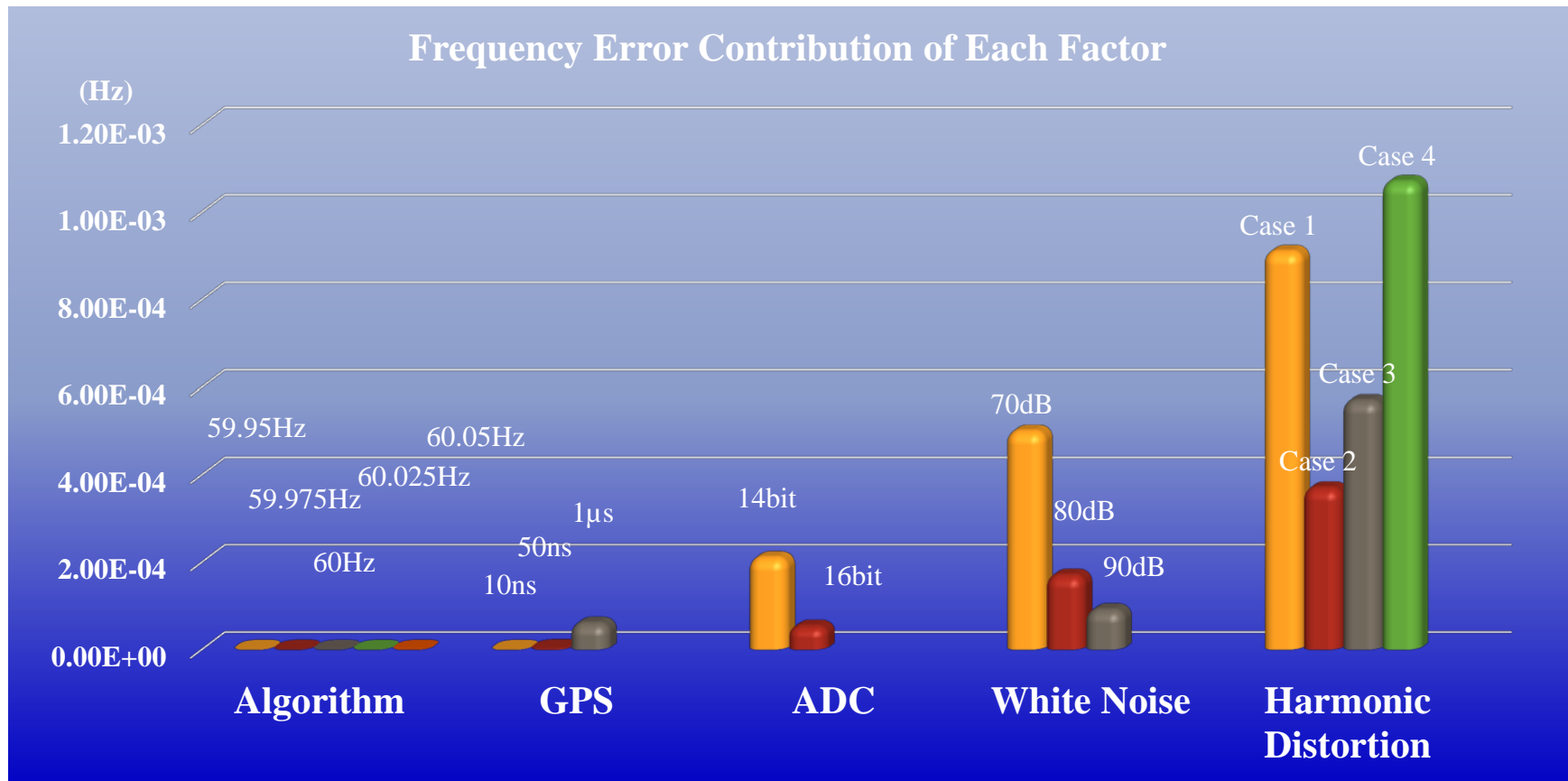
Angle Error Contribution

- $f = 59.95 \text{ Hz}$



Frequency Error Contribution

- $f = 59.95 \text{ Hz}$



Thank You!

Questions/Comments?

