Probing-Based Inertia Estimation Method Using Hybrid Power Plants

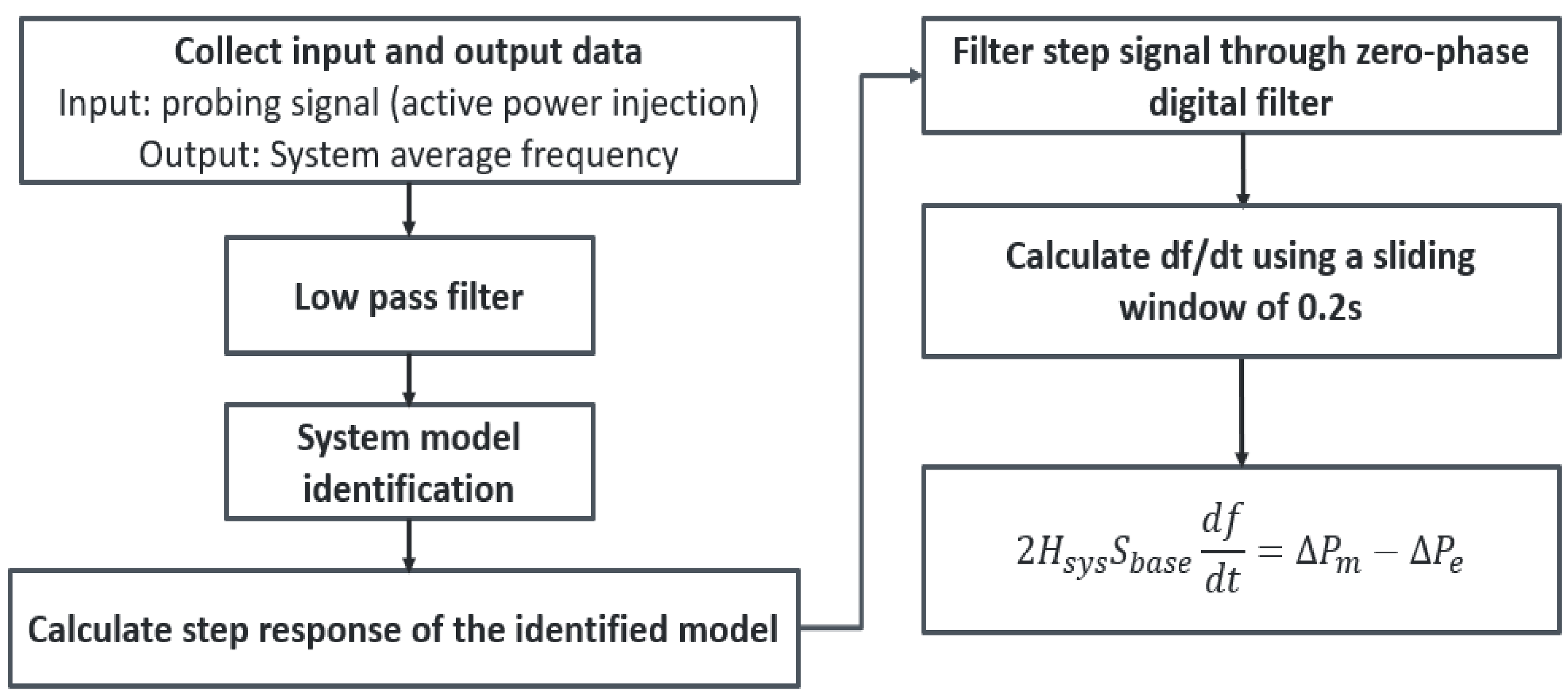
Zhihao Jiang[1], He Yin[1], Hongyu Li[1], Yilu Liu[1,2], Jin Tan[3], Andy Hoke[3], Brad Rockwell[4], Cameron Kruse[4]
[1] The University of Tennessee, Knoxville
[2] Oak Ridge National Laboratory
[3] National Renewable Energy Laboratory
[4] Kauai's Island Utility Cooperative

Background and Motivation

- Power systems face the challenge of reduced inertia with the displacement of conventional synchronous generation with inverter-based resources (IBRs)
- IBRs could provide fast frequency responses (FFR), contributing to system equivalent inertia
- There are rising needs of monitoring system inertia for situational awareness
- Event-based inertia estimation is affected by system operating conditions and could not reflect real-time inertia.
- Hybrid power plants with battery energy storage system (BESS) could inject active power as a probing signal.

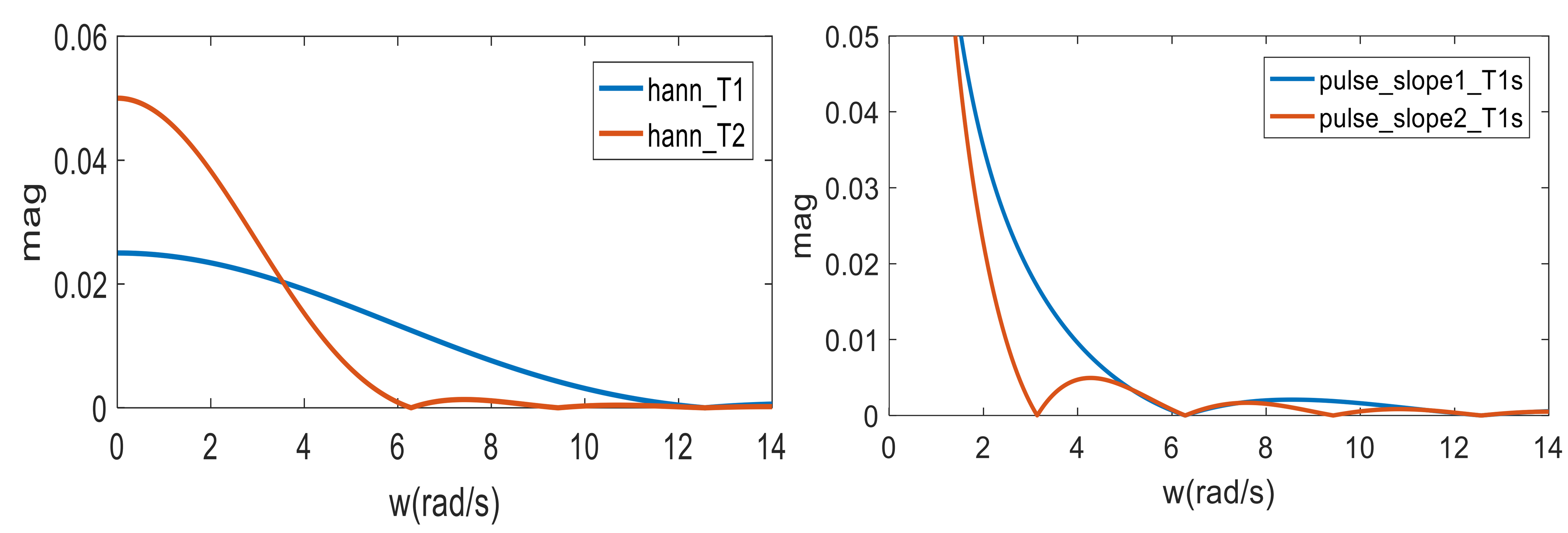
Methodology

- Utilize BESS to inject active power pulses into the grid and estimate system inertia using frequency measurements



Probing signal selection

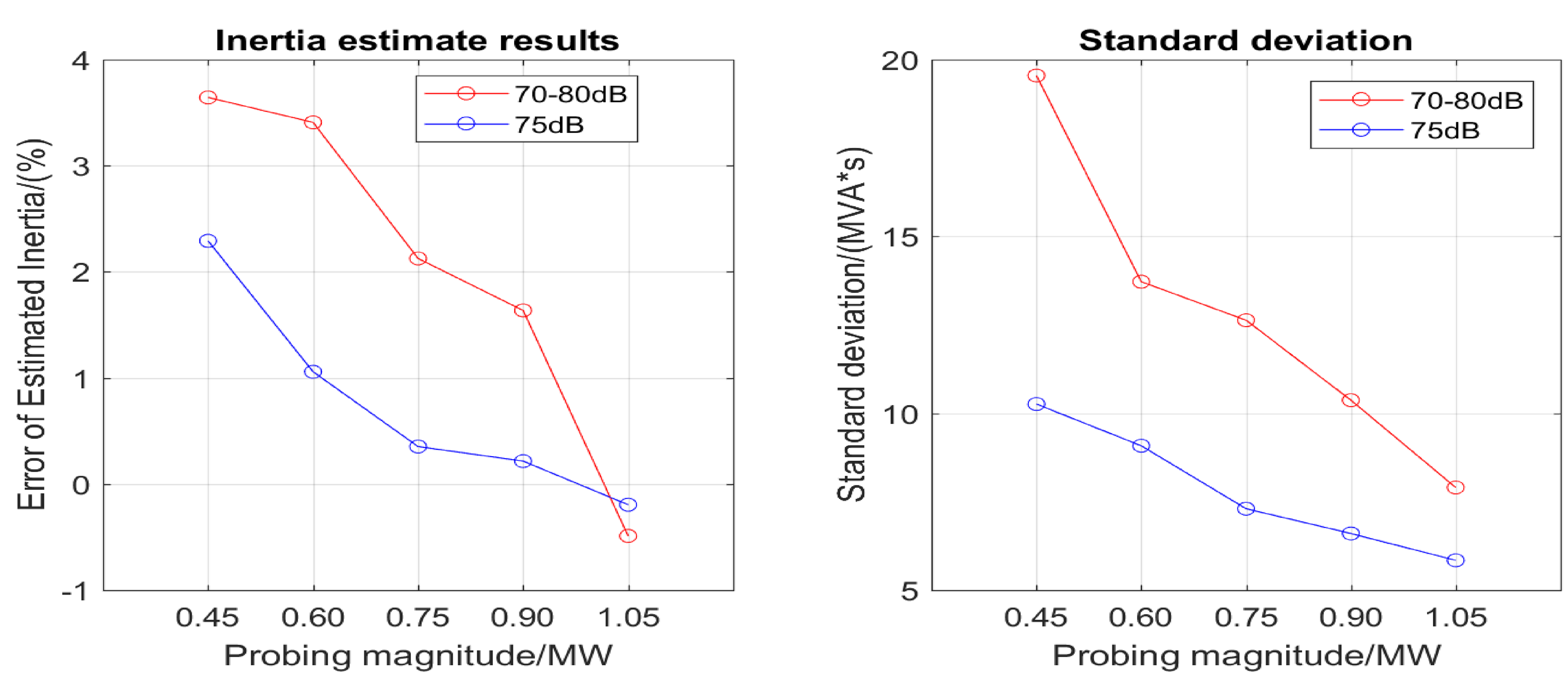
- Frequency spectrum of the probing signal should concentrate in the frequency range of inertia response (0-0.5Hz)
- Magnitude of the probing signal should be selected so that frequency disturbances are kept within acceptable limits
- Frequency noise caused by load fluctuations need to be considered
- Hann signal with a duration of 2s, magnitude around 1MW is suitable for KIUC system



Frequency spectrum of different probing signals

Simulation test

- Validate the proposed method in KIUC PSS/E model with emulated noise level
- Noise level is estimated based on measurements from Universal Grid Analyzer (UGA) deployed on Kauai island
- Higher probing magnitude could improve accuracy and belittle load fluctuations
- Further investigation is needed to understand contribution of different forms of FFR to equivalent inertia and develop quantification method



Prob mag/MW	Average		Standard deviation	
	No FFR	With FFR	No FFR	With FFR
0.45	**105.51**	**110.96**	**16.96**	**18.18**
0.60	**104.36**	**115.65**	**13.08**	**15.47**
0.75	**104.24**	**124.92**	**10.12**	**16.65**
0.90	**104.16**	**128.66**	**8.45**	**19.02**
1.05	**103.64**	**137.28**	**7.55**	**19.72**