Data-Driven Model Predictive Control for Fast-Frequency Support

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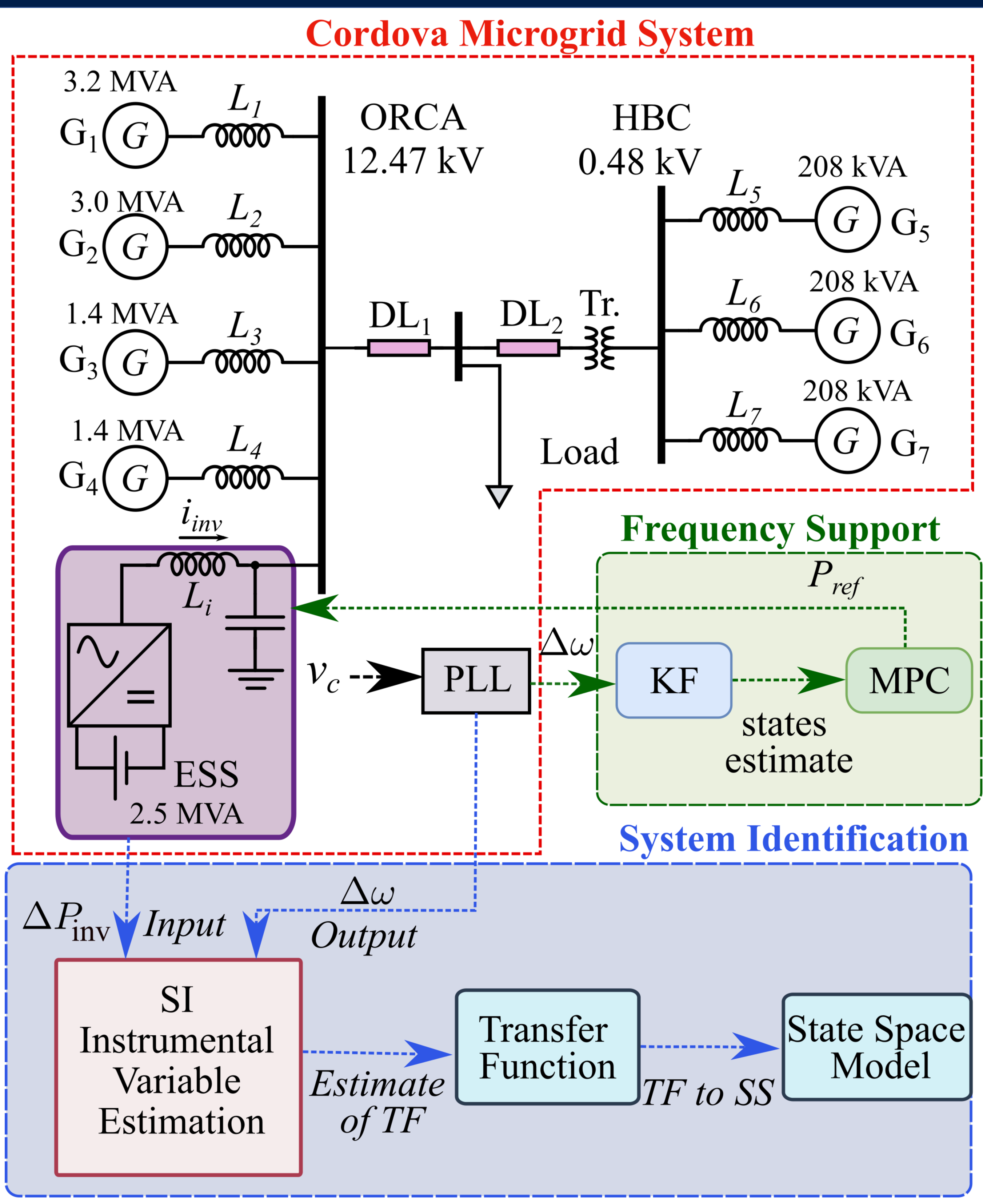
Motivation and Objectives

- Grid→ rotational to converter dominated
  - ➢ Creates challenges for reliable operation
  - ➢ Requires new modeling, estimation, control
- August 9, 2019, UK blackout: frequency event
  - ➢ Lasted 45 minutes
  - ➢ Affected 1 million people
- Model predictive control (MPC) based approach to achieve fast frequency response in ESS
  - ➢ Handles operational constraints and cost and flexible to adjust performance
  - ➢ Challenges: accurate prediction model
- Power system expands and dynamic changes over time
- Data-driven model : Builds mathematical model based on observed data
  - ➢ Without prior assumption of power system dynamics
- Contribution:
  - ➢ Implementation of data-driven MPC for fast-frequency support
  - ➢ Comparison with standard MPC

Proposed Framework



Excitation Signal

- Logarithmic square chirp
- Amplitude: 0.05 p.u.
- Frequency range: 0.02Hz-3Hz
- Time period = 250s

MPC Settings:

- Sample Time (T_s)=0.02s
- Weights: Q_{MPC}=diag(0.2, 0.5); R=0.005[1]
- Horizon length (N) = 50

KF Settings:

- T_s=0.02s; measurement noise = 65dB[1]
- Q_{KF}= diag($300 \times 10^{-9}, 2 \times 10^{-8}, 2.5 \times 10^{-8}, 200 \times 10^{-8}$)

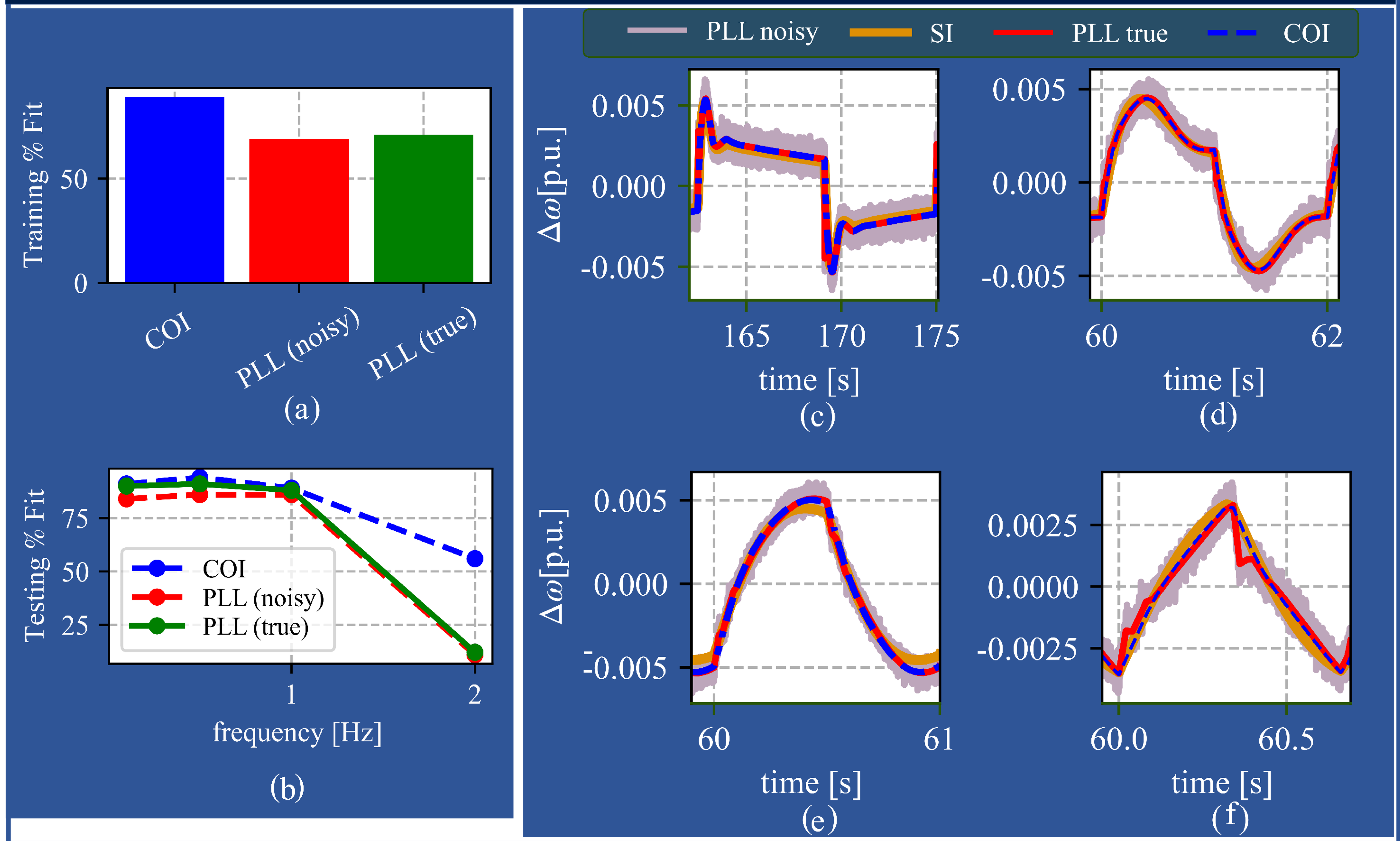
- Two parts: modeling and fast frequency support
- Data-driven system identification on Cordova benchmark[1]
  - ➢ Square log chirp signal to perturb the system
  - ➢ Collect input and output data
  - ➢ Estimate transfer function model
  - ➢ Change into state-space model
- Frequency support using Kalman filter (KF)-MPC :KF estimates states for MPC

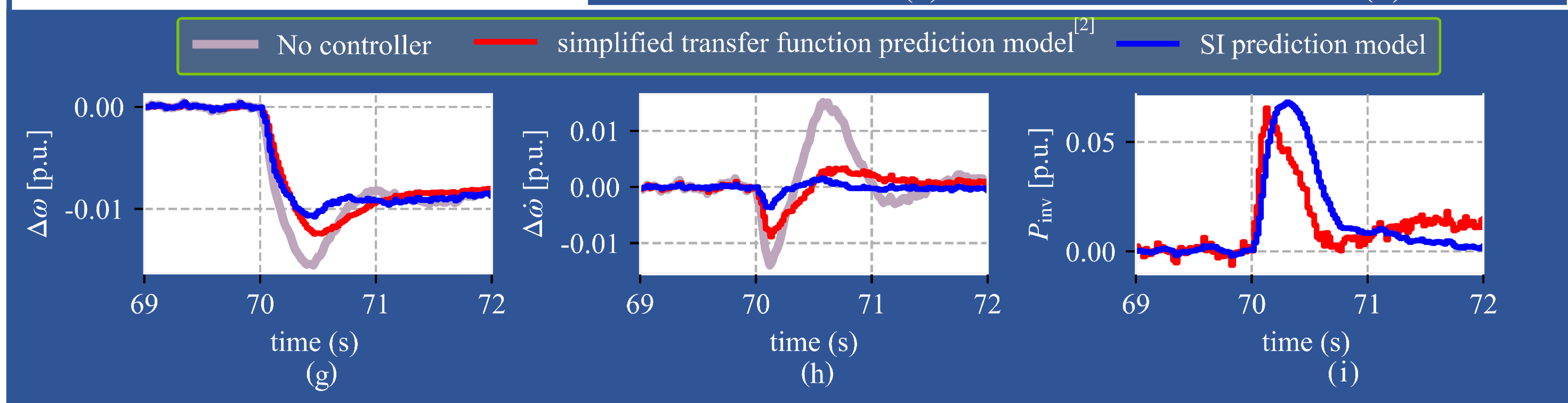
SI MPC	Standard MPC
SI estimates predictive model	transfer function model with known system parameters

- Same MPC settings for fair comparison

- Comparison of two predictive models for frequency support
  - ➢ KF tuned to perform similar results
- Phase-locked loop (PLL) provides noisy frequency measurement
- Center of inertia (COI) gives better estimation frequency
- At t=70s, step-change of load from 0.5 p.u. to 0.7 p.u.

Simulation Result and Analysis





- SI predictive model similar to TF model however has different coefficients
- SI-based MPC provides a lower frequency deviation and ROCOF

Conclusion and Future Work

- Implemented SI in MATLAB/Simulink to predict the model of a microgrid.
- SI predictive model for similar to TF model however has different coefficients
- Result showed that the SI-based MPC → suitable model
- Limited bandwidth of PLL limits the frequency range of input signal
- Generalize SI methodology for different test systems and conditions
- Perform state-of health of microgrid

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References

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