

Dynamic Monitoring of Electrical Grids

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Challenges and objectives

Challenges and changes:

- Introduction of distributed energy resources (DER) such as wind-farms and photovoltaic (PV) generation:
 - I. Unidirectional power flows.
 - II. providing great quantities of generation makes control of surrounding distribution systems' voltage and frequency more complicated.
 - III. Unpredictable charge and discharge profiles.
- Changes in electrical load behavior.
- Introduction of Phasor measurement units (PMUs) and smart meters.
- Consumers' privacy consideration
- PMUs are expensive.

Objective:

Dynamic monitoring at the distribution level.

Significant results

- Kalman filtering derivation and extension of simultaneous input and state estimation. Automatica, 2019

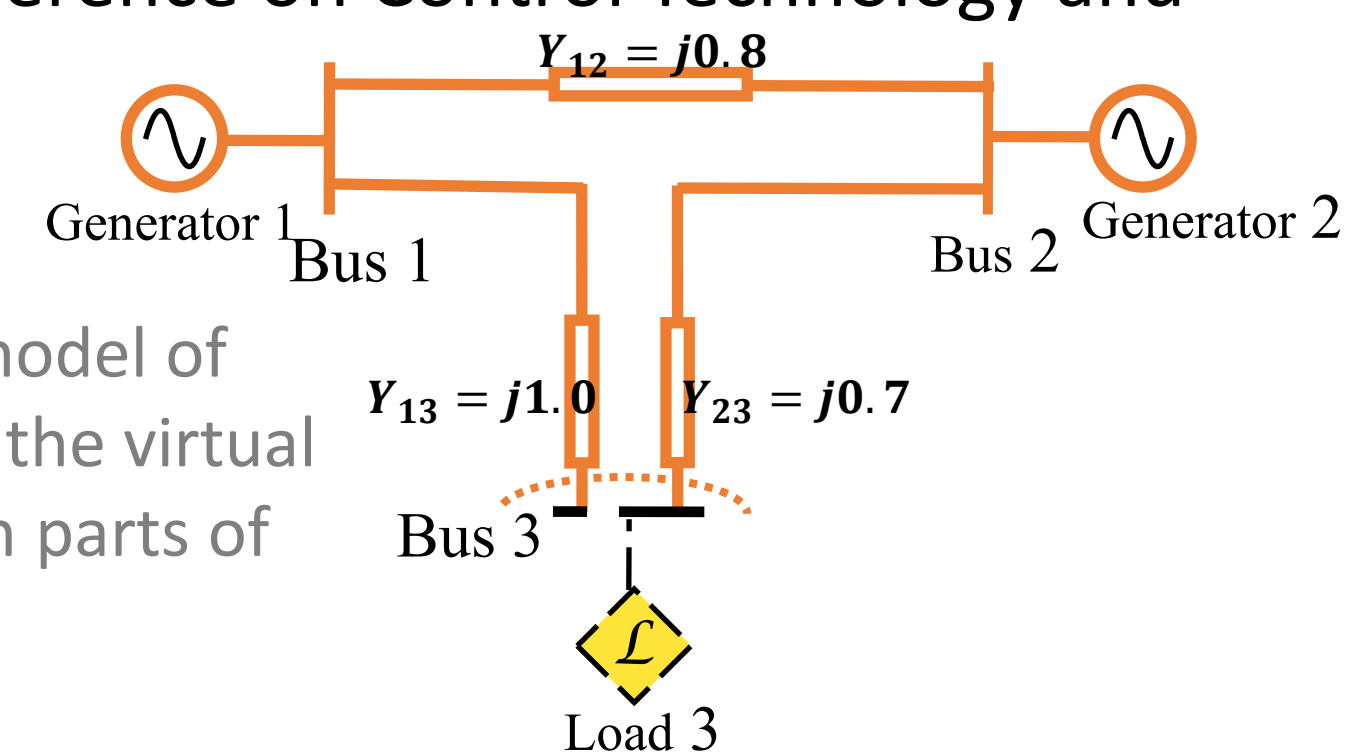
Linear time-invariant model:

$$\begin{aligned} x_{t+1} &= Ax_t + Gd_t + w_t \\ y_t &= Cx_t + v_t \end{aligned}$$

Assumptions:

1. Initial conditions and noise sequences are Gaussian and independent.
2. $\text{rank } CG = \text{rank } G = m$.

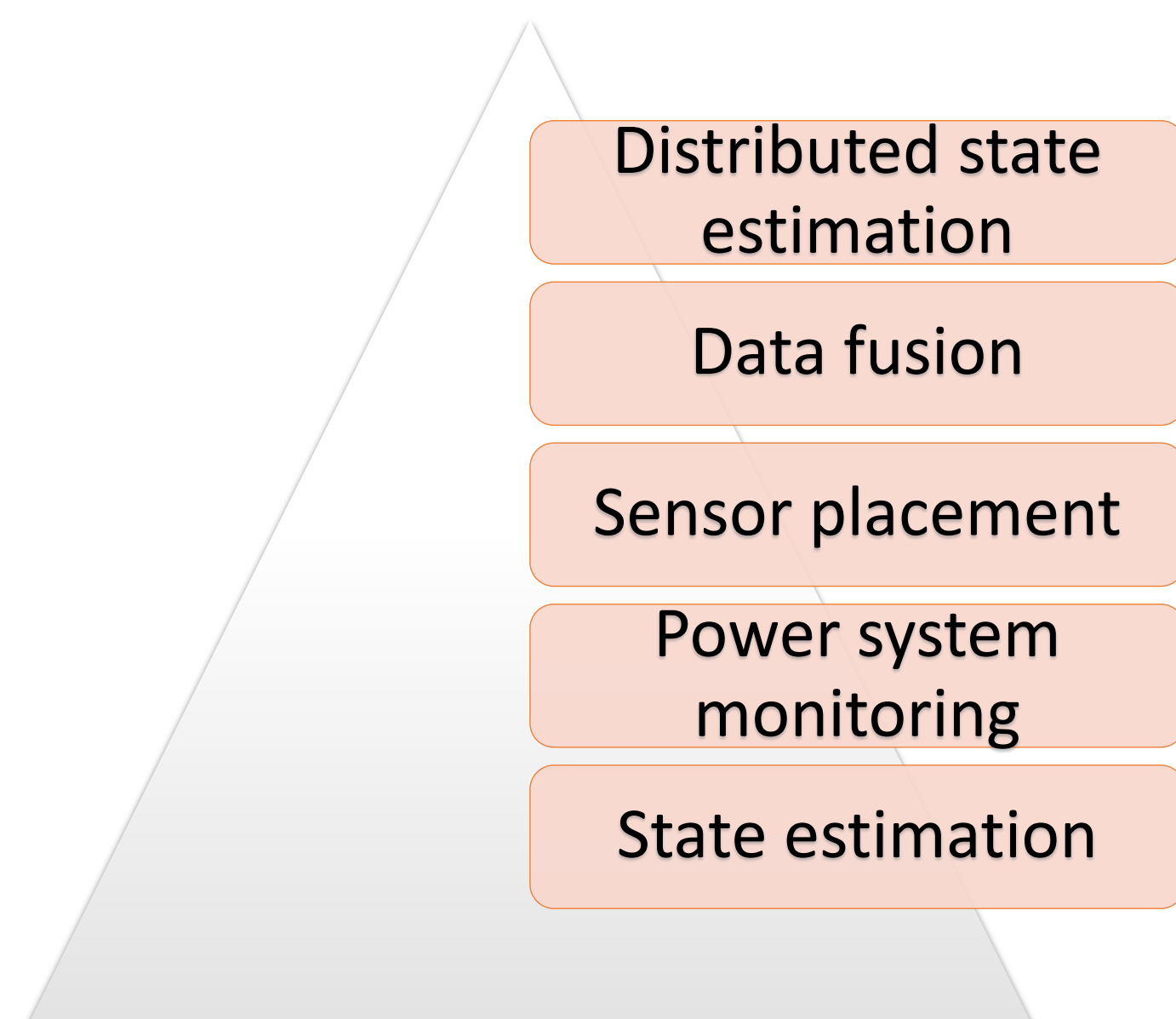
- Disturbance and State Estimation in Partially Known Power Networks. 2019 IEEE Conference on Control Technology and Applications (CCTA),



Transformer-less dynamic power grid model of IEEE-3-bus. The dashed line represents the virtual cut separating the known and unknown parts of the network.

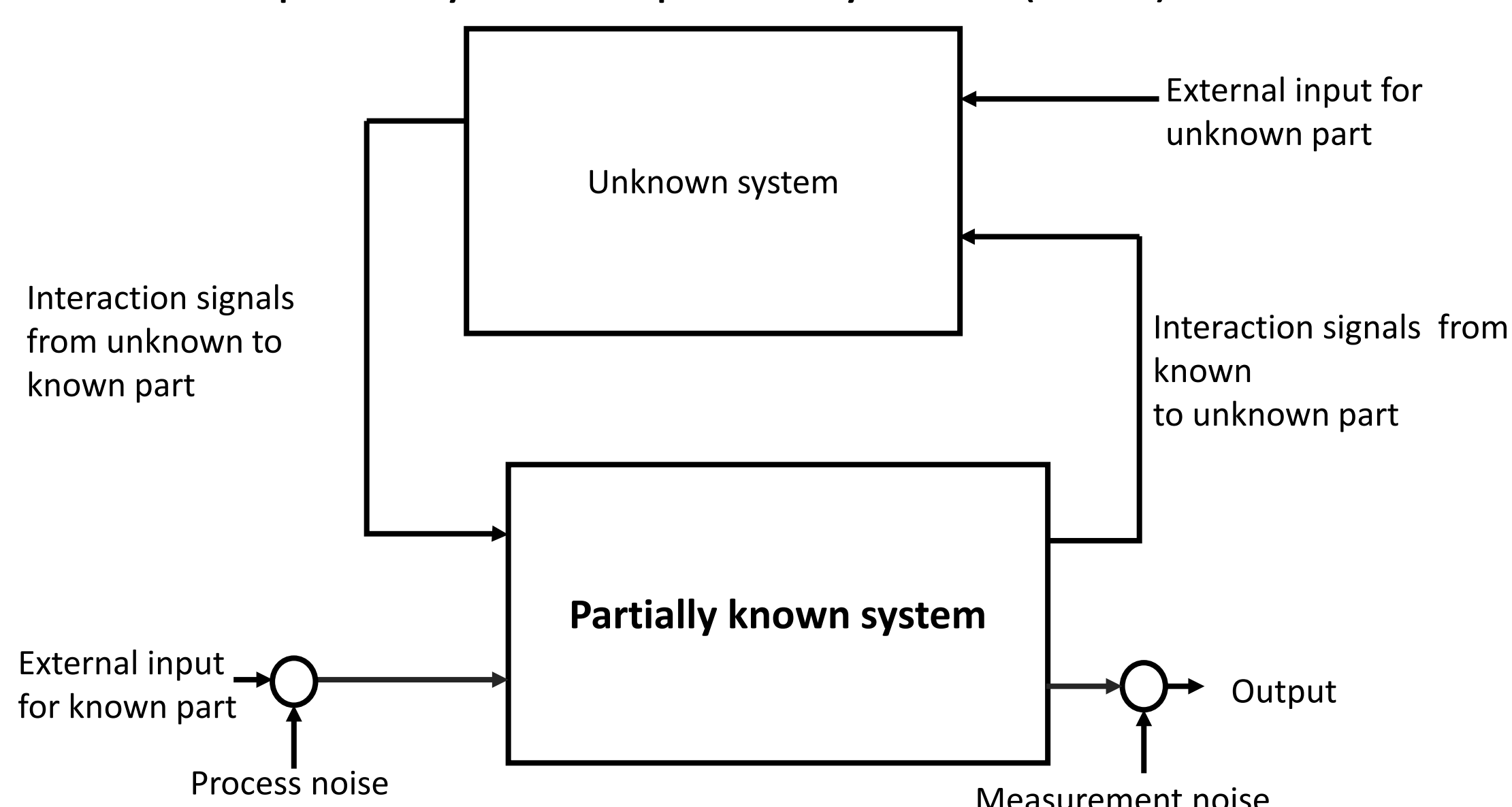
- Monitoring Disturbances and States in Partially Known Power Systems, IEEE Transactions on Power Systems (submitted-under review).
- A Covariance Consistent Data Fusion method for Power Networks with Multirate Sensors. 2020 IEEE Conference on Control Technology and Applications (CCTA),
- Distributed H-infinity Filtering for Linear and Nonlinear Systems, 2021 American Control Conference (ACC) (submitted-under review).
- Sensor placement for partially known power networks, 2021 IEEE Conference on Control Technology and Applications (CCTA) (to be prepared),
- Dynamic state estimation and data fusion in power networks, IEEE Transactions on Power Systems (to be prepared)

Research tasks



Approach

- Deconstruct simultaneous input and states estimation (SISE).
- Stabilize the estimation method with improved observability
- Introduce partially known power systems (PKPS) state estimation



- For sensor placement, greedy algorithm is investigated
- Different data fusion methods including the covariance intersection and Bar-Shalom-Campo are applied.

Figures

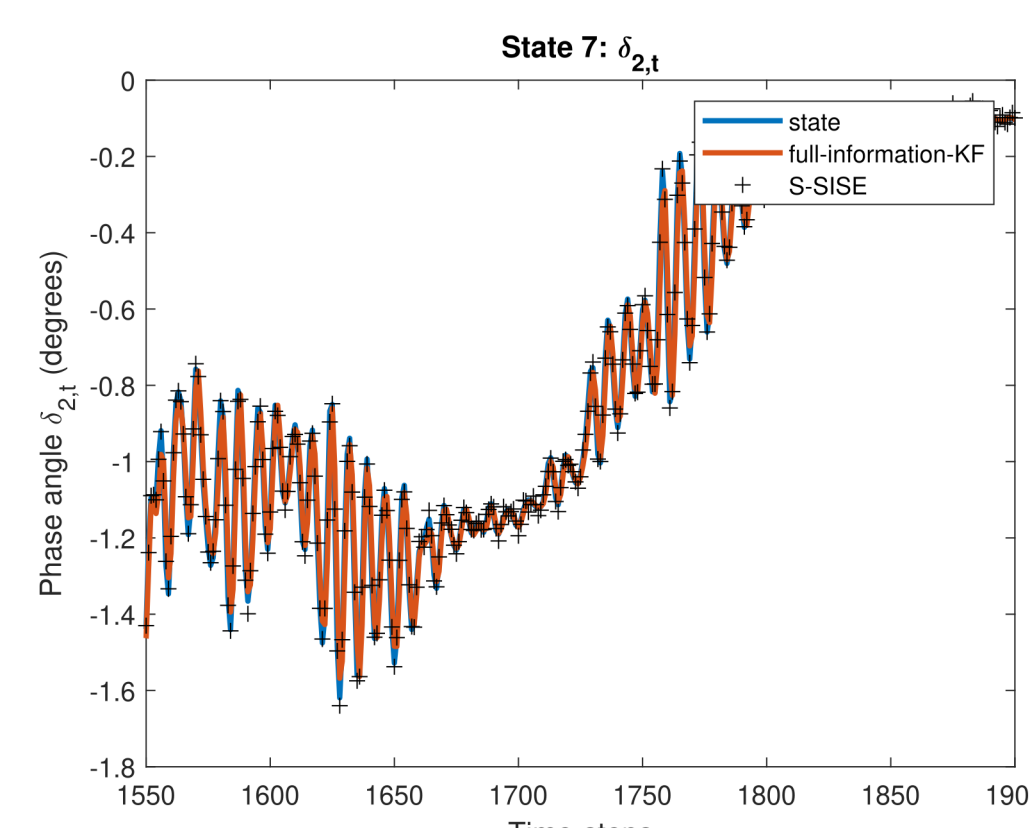


Fig. 1: Power angle at bus 2 and their estimates

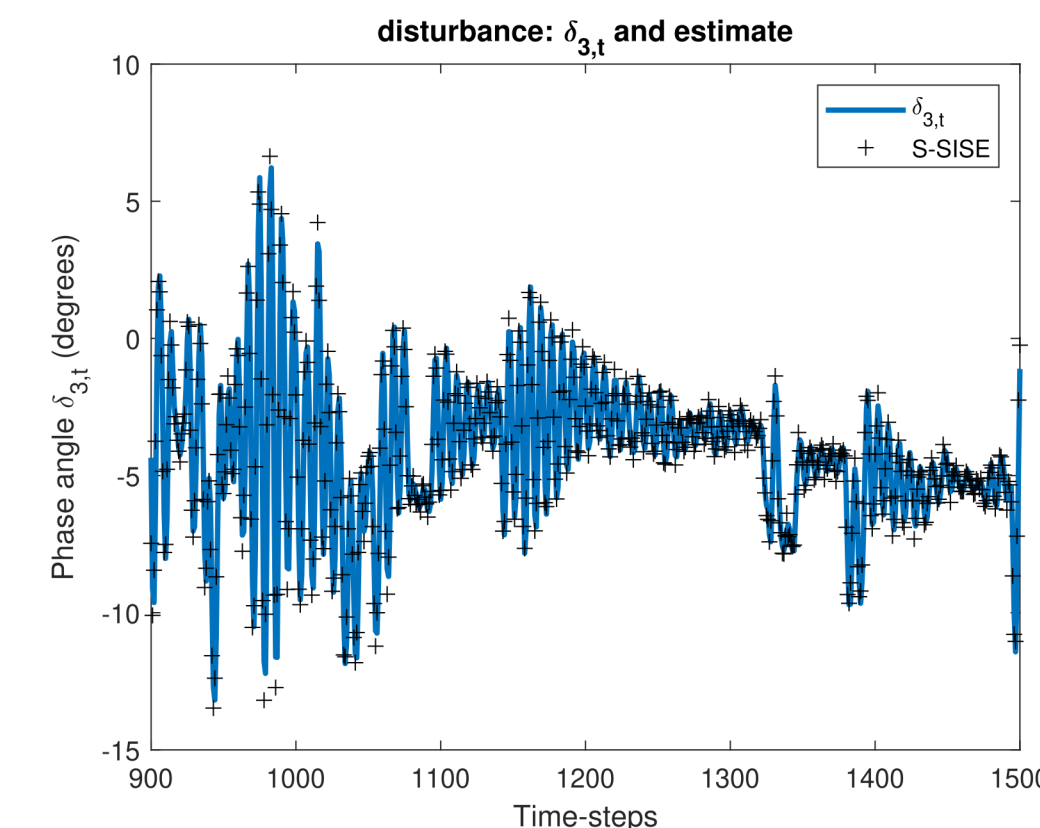


Fig. 2: External input/disturbance in blue and its estimates