

A Generalized Open Source Platform Design for Building Energy Management

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Objectives

- Implement microgrid state estimation algorithm in [2] in MATLAB
- Research new device to add to BEMOSS

State Estimation Algorithm

State Estimation Algorithm

By using KVL and KCL,

$$\text{DER}_i \begin{cases} \dot{V}_{i,dq} = -j\omega_0 V_{i,dq} + (d_i I_{ti,dq} + I_{ij,dq})/C_{ti} \\ \dot{I}_{ti,dq} = -j\omega_0 I_{ti,dq} - (d_i V_{i,dq} + R_{ti,dq} I_{ti,dq} - V_{ti,dq})/L_{ti} \end{cases}$$

$$\text{DER}_j \begin{cases} \dot{V}_{j,dq} = -j\omega_0 V_{j,dq} + (d_j I_{tj,dq} + I_{ji,dq})/C_{tj} \\ \dot{I}_{tj,dq} = -j\omega_0 I_{tj,dq} - (d_j V_{j,dq} + R_{tj,dq} I_{tj,dq} - V_{tj,dq})/L_{tj} \end{cases}$$

$$\dot{I}_{ij,dq} = -j\omega_0 I_{ij,dq} + (V_{j,dq} - R_{ij,dq} I_{ij,dq} - V_{i,dq})/L_{ij}$$

$$\dot{I}_{ji,dq} = -j\omega_0 I_{ji,dq} + (V_{i,dq} - R_{ji,dq} I_{ji,dq} - V_{j,dq})/L_{ji}$$

State Estimation Algorithm

In more compact form,

$$\dot{\mathbf{x}} = \mathbf{A}\mathbf{x} + \mathbf{B}\mathbf{u}$$

In discrete time,

$$\mathbf{x}(k+1) = \mathbf{A}_d\mathbf{x}(k) + \mathbf{B}_d\mathbf{u}(k) + \mathbf{n}_d(k)$$

where

$$\mathbf{x} = [V_{i,d}, V_{i,q}, I_{ti,d}, I_{ti,q}, I_{ij,d}, I_{ij,q}, I_{ji,d}, I_{ji,q}, V_{j,d}, V_{j,q}, I_{tj,d}, I_{tj,q}]'$$

$$\mathbf{u} = [V_{ti,d}, V_{ti,q}, V_{tj,d}, V_{tj,q}]'$$

$$\mathbf{A}_d = \mathbf{I} + \mathbf{A}\Delta t$$

$$\mathbf{B}_d = \mathbf{B}\Delta t$$

and \mathbf{A} and \mathbf{B} are defined in [1] and [2] respectively.

State Estimation Algorithm

Sensory measurements are made around the grid to estimate voltage.

$$\mathbf{y}^i(k) = \mathbf{C}^i \mathbf{x}(k) + \mathbf{w}^i(k)$$

where $i = 1, 2, \dots, n$. $\mathbf{y}^i(k)$ is the observations made, \mathbf{C}^i is the sensing matrix, and $\mathbf{w}^i(k)$ is the measurement noise with zero mean and covariance \mathbf{R}^i .

State Estimation Algorithm

Distributed state estimation:

$$\begin{aligned}\hat{\mathbf{x}}^i(k+1) = & \mathbf{A}_d \hat{\mathbf{x}}^i(k) + \mathbf{B}_d \mathbf{u}(k) + \mathbf{K}^i(k)[\mathbf{y}^i(k) - \mathbf{C}^i \hat{\mathbf{x}}^i(k)] \\ & + \mathbf{L}^i(k) \sum_{j \in \mathcal{N}_i} [\hat{\mathbf{x}}^j(k) - \hat{\mathbf{x}}^i(k)]\end{aligned}$$

where $\mathbf{L}^i(k)$ is the neighboring gain and $\mathbf{K}^i(k)$ is the local gain.

Further tasks

- Research and start implementing new device
- Start developing new BEMS from scratch

For Further Reading I

 S. Rivero, F. Sarzo, and G. Ferrari-Trecate

Plug-and-play voltage and frequency control of islanded microgrids with meshed topology

IEEE Transactions on Smart Grid, vol. 6, no. 3, pp. 1176-1184, May 2015.

 M.M. Rana, L. Li, S. W. and W. Xiang

Consensus-Based Smart Grid State Estimation Algorithm.

IEEE Transactions on Industrial Informatics, vol. 14, no. 8, pp. 3368-3375, Aug. 2018.

Any questions?