A Generalized Open Source Platform Design for Building Energy Management

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Outline

Objectives

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

State Estimation Algorithm

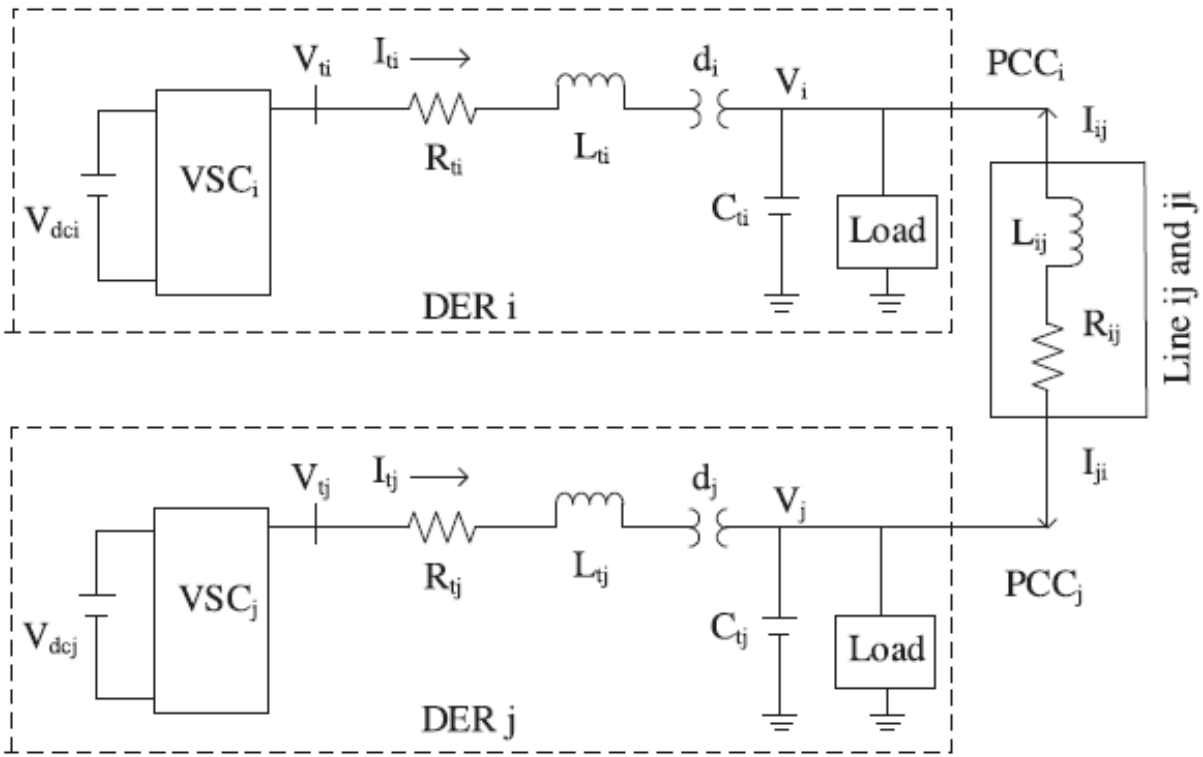

Figure: Schematic of microgrid used in state estimation algorithm containing 2 Distributed Energy Resources (DERs)

State Estimation Algorithm

By using KVL and KCL,

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

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

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

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

State Estimation Algorithm

In more compact form,

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

In discrete time,

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

where

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

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

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

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

and $\boldsymbol{A}$ and $\boldsymbol{B}$ are defined in [?] and [?] respectively.

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State Estimation Algorithm

Sensory measurements are made around the grid to estimate voltage.

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

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

State Estimation Algorithm

Distributed state estimation:

$$\hat{\boldsymbol{x}}^i(k+1) = \boldsymbol{A}_d\hat{\boldsymbol{x}}^i(k) + \boldsymbol{B}_d\boldsymbol{u}(k) + \boldsymbol{K}^i(k)[\boldsymbol{y}^i(k) - \boldsymbol{C}^i\hat{\boldsymbol{x}}^i(k)] + \boldsymbol{L}^i(k)\sum_{j\in N_i}[\hat{\boldsymbol{x}}^j(k) - \hat{\boldsymbol{x}}^i(k)]$$

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

Further tasks

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

For Further Reading I

S. Riverso, 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?