Advancing Distribution System State Estimation for Solar Grid Integration

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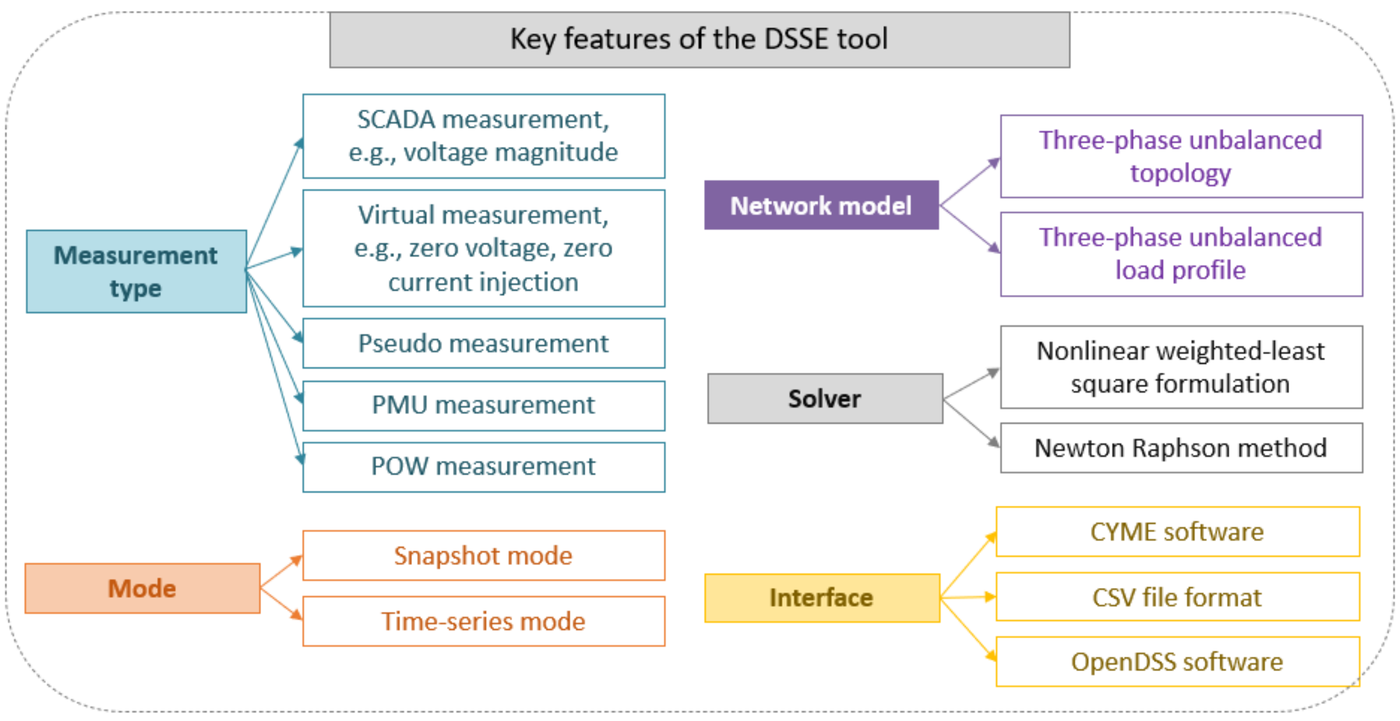
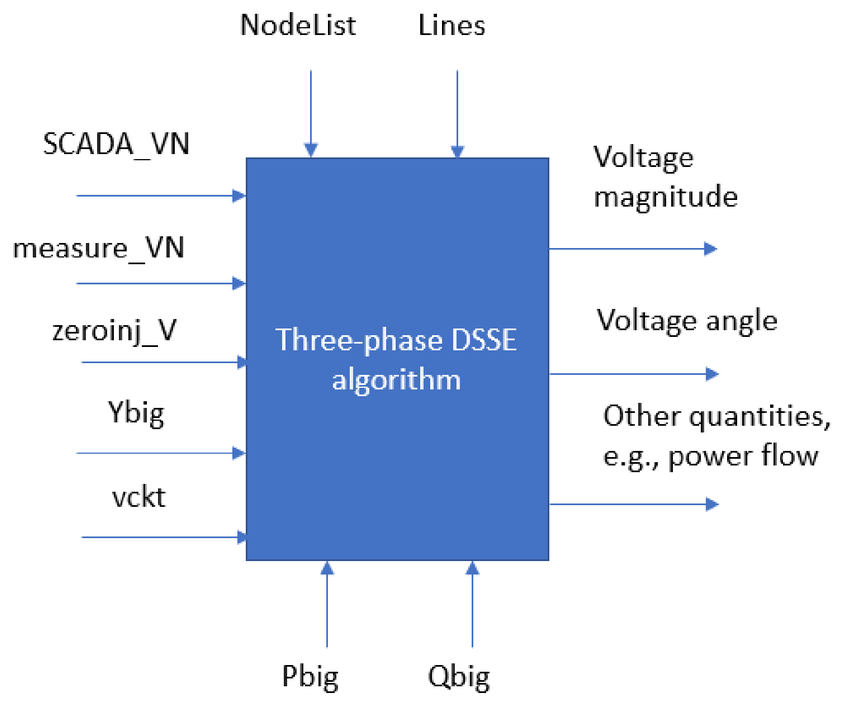
Problem Description

- Current distribution system models face limitations in meeting the growing demands of solar integration R&D.
- Lacking tools such as state estimation for testing user-defined algorithms to address solar integration challenges.
- Accurate situational awareness of distribution networks requires novel state estimation tools that integrate various available measurements.

Proposed Solution





Methodology

- Formulate the DSSE as a nonlinear weighted least square (WLS) problem and solves it by the Newton Raphson method
- State variables are selected as the rectangular coordinates of the three-phase voltage phasor
- Three-phase measurement equations and Jacobian matrices are fully modeled
- Dimension of the Jacobian matrix is around 3 times of the number of the nodes
- Two implementation strategies of DSSE:

$$\begin{bmatrix} P_i \\ Q_i \end{bmatrix} = \begin{bmatrix} f_i & e_i \\ -e_i & f_i \end{bmatrix} \begin{bmatrix} \sum_{k\in\varphi_i}(G_{ik}f_k + B_{ik}e_k) \\ \sum_{k\in\varphi_i}(G_{ik}e_k - B_{ik}f_k) \end{bmatrix}$$

Three-phase decoupled DSSE strategy: Concatenating the three-phase measurements and directly utilizing the conventional transmission system single-phase state estimation algorithm;

$$\begin{bmatrix} P_i^d \\ Q_i^d \end{bmatrix} = \begin{bmatrix} f_i^d & e_i^d \\ -e_i^d & f_i^d \end{bmatrix} \begin{bmatrix} \sum_{k\in\varphi_i}\sum_{t\in B_1}(G_{ik}^{dt}f_k^t + B_{ik}^{dt}e_k^t) \\ \sum_{k\in\varphi_i}\sum_{t\in B_1}(G_{ik}^{dt}e_k^t - B_{ik}^{dt}f_k^t) \end{bmatrix}$$

Three-phase coupled DSSE strategy: Fully consider the three-phase information

Case Study

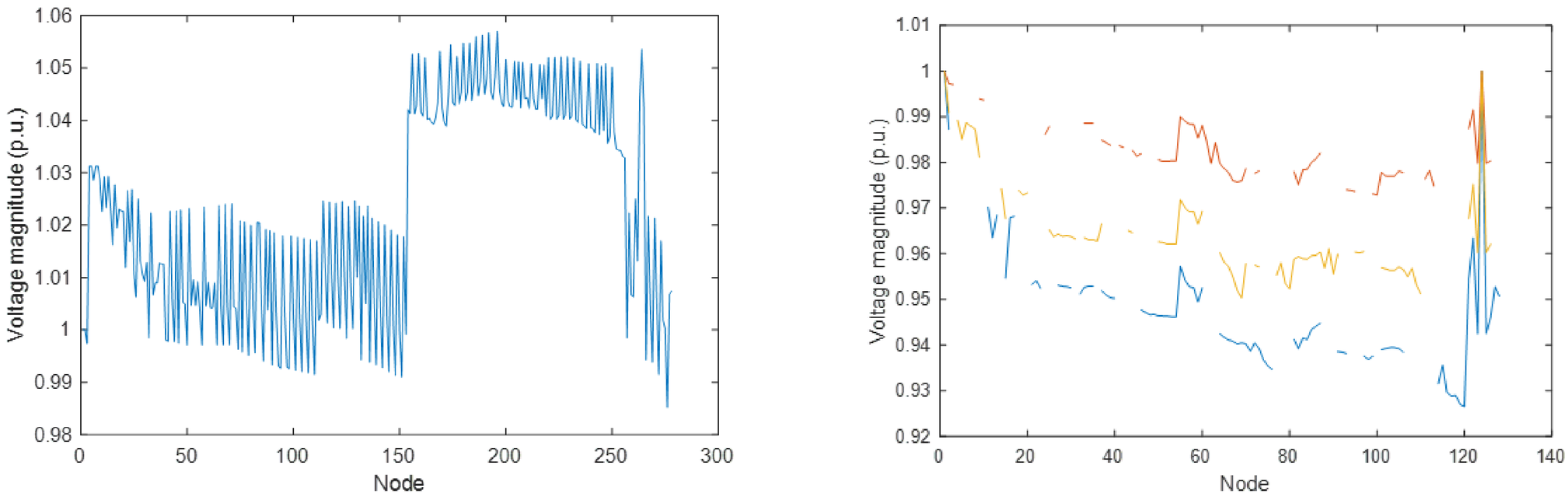


Figure. (a) Estimated voltage magnitude of the three-phase **decoupled** DSSE algorithm (b) Estimated voltage magnitude of the three-phase **coupled** DSSE algorithm

Conclusion

- A novel DSSE tool has been developed that handles multiple available measurements in distribution systems.
- SCADA, PMU, POW, virtual, and pseudo measurements are modeled in the tool.
- The tool can be used for testing user-defined algorithms and assessing the impacts of different measurements.