Enhanced Dynamic Equivalent Identification Method of Large-Scale Power Systems Using Multiple Events

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Zhihao Jiang¹, Ning Tong¹, Yilu Liu¹,², Yaosuo Xue², Alfonso G. Tarditi²
1- University of Tennessee
2- Oak Ridge National Laboratory
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Background and motivation
- Develop measurement-based dynamic equivalents to represent the external area
- Speed up dynamic simulation for large-scale power grids
- Improve robustness of dynamic equivalents under different operating conditions

Technical approach
- Derive dynamic equivalents of external system based on transfer function between tie line flow and PMU measurements on the boundary
- Improve robustness of equivalents by involving multiple events in the parameterization process
- Cluster candidate events into different groups based on similarity indices
- Select representative events in each group to form the training set

Conclusion
- Improved computation speed of dynamic simulation subject to different types of contingency
- Developed strategy to select multiple training events by clustering based on similarity indices between different candidate events
- Improved the robustness of the dynamic equivalents under changing system conditions

Fig 1. Correlation indices map
Fig 2. Dynamic responses (single vs. multiple training)
Methodology

- Replaced tie lines with equivalent loads modeled as transfer function between P/Q and boundary PMU measurements based on system identification

\[
\begin{align*}
    P_i(s) &= G_{i1}(s)f_i(s) + G_{i2}(s)V_i(s) \\
    Q_i(s) &= G_{i3}(s)f_i(s) + G_{i4}(s)V_i(s)
\end{align*}
\]

- Only single event data used for system identification in previous work
- Multiple events training
  Cluster candidate events into different groups based on similarity indices calculated as the correlation coefficient of the dynamic response of tie line flow between different events

\[
\rho(A, B) = \frac{1}{N-1} \sum_{i=1}^{N} \left( \frac{A_i - \mu_A}{\sigma_A} \right) \left( \frac{B_i - \mu_B}{\sigma_B} \right)
\]
Case Study

Testing scenarios

- Scenario 1: Generation trip @ bus 57,300MW (same group as the event used for single event training)
- Scenario 2: Generation trip @ bus 98,600MW (different group as the event used for single event training)
- Training set #1: single event training
- Training set #2: multiple events training
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