Analytical Tools of Small-Signal Converter-Driven Stability for Transmission Grids

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INTRODUCTION

- Converter-driven stability (CDS) is a new stability class introduced by addition of emerging power electronics technologies into power system.
- This work aims to adopt a more strategic approach at addressing the evolving CDS concerns in practical high-renewable penetration transmission grids.
- The objectives of the project include:

a) an innovative impedance-based small-signal stability criterion suitable for large-scale power grids' analysis,
b) decomposition of large power electronics-based power system into subsystems to reduce computational complexity, and
c) a small-signal converter-driven stability analytical tool, which can be used for future large-scale 100% renewable grid planning and design to guarantee secure and stable operation.

TASKS AND TECHNICAL APPROACHES

- **Develop impedance-based small-signal stability criteria for large-scale power electronics-based power system**: Impedance-based approach such as Nodal admittance matrix (NAM) uses terminal characteristics, making it the preferred choice for PE-rich power systems' stability analysis.

- **System decomposition of large-scale power electronics-based power system**: NAM-based criterion is applied to the entire system, thereby increasing computational demands. Goal is to decompose the large-scale system into subsystems to reduce computational burden.

- **Systematic approach to decomposition large-scale power electronics-based power system**: The goal is to efficiently decompose a large power electronics-based power system into subsystems to reduce computational complexity in small signal stability analysis.

- **Design of stability detection tool with user-friendly graphical user interface**: The analytical tool will incorporate the enhanced small-signal stability criterion, standardized data prerequisites, decomposition algorithm, showcasing its effectiveness in a transmission grid test system.

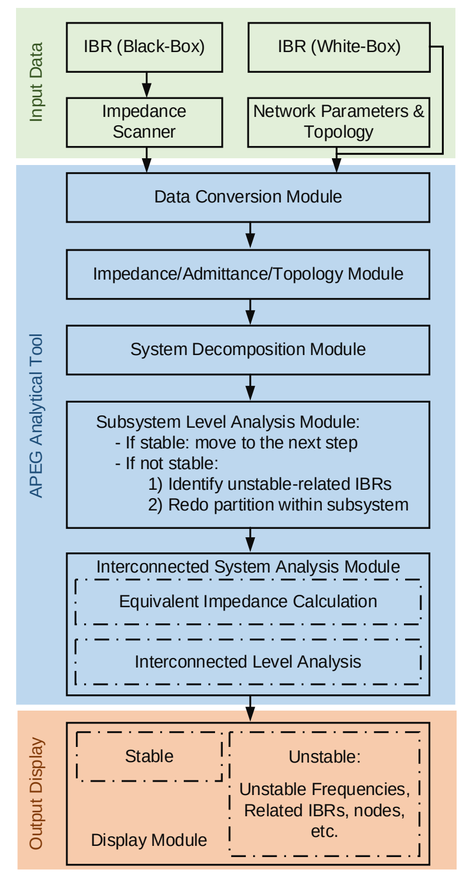

Fig. 1. Architecture of stability detection tool.

RESULTS

- Proposed nodal admittance matrix-based area partition method for small-signal stability analysis of large-scale power electronics-based power systems.

- Developed a preliminary stability detection tool with user-friendly graphical user interface.

- Quantified the computational complexity of the nodal-admittance-matrix based method: Computation complexity of partition based-NAM is compared with the original method.

- To systematically decompose the large-scale power-electronics-based power system using a well-known graph theory method, namely the spectral clustering algorithm.

- This algorithm entails constructing a graph representation of data points, computing its Laplacian matrix, and extracting eigenvalues and eigenvectors.

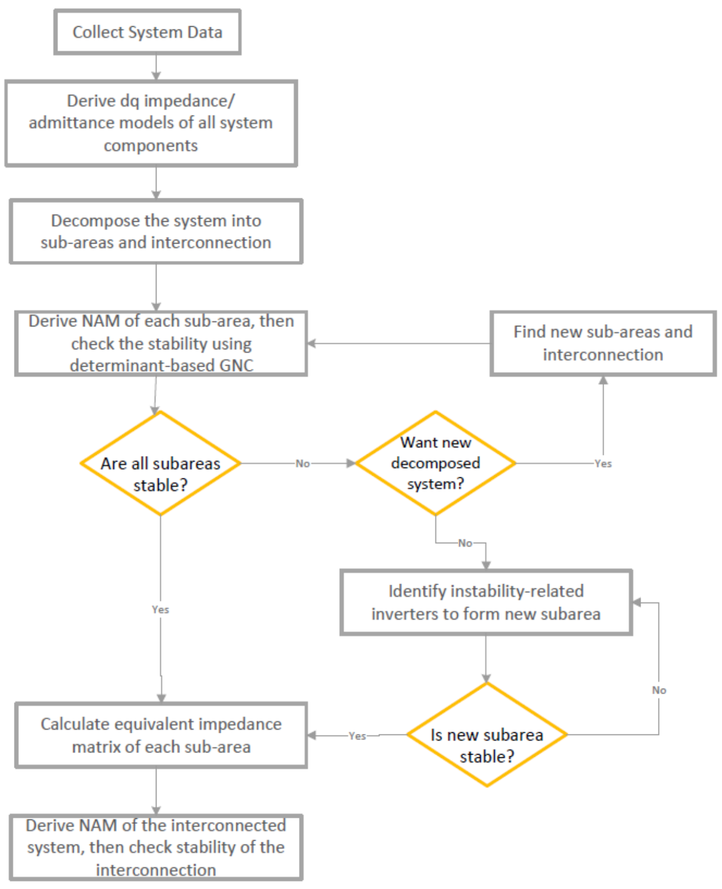

Fig. 2. Flow chart of the NAM-based area partition method.

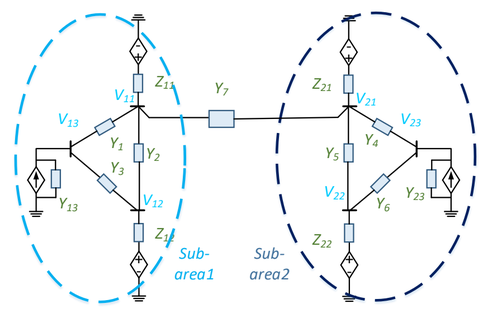

Fig. 3. Two subsystems of six-converter system.

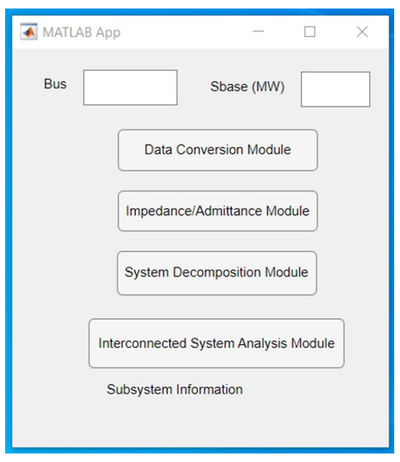

Fig. 4. UI analyses the 6-converter system.

CONCLUSION

- Proposed method is more scalable, flexible, offers additional stability insights about subareas and their interconnecting lines.
- Focuses on decomposing the overall system so that the computation burden reduction is always guaranteed.
- In certain instances, even if computational complexity remains unchanged, proposed method improves the ease of analyzing & managing the system.

REFERENCE

- L.Qiao, et. al., "Nodal admittance matrix-based area partition method for small-signal stability analysis of large-scale power electronics-based power systems," in IEEE Appl. Power Electron. Conf. Expo., 2021, pp. 687-693.