INTEGRATING GRID-CONNECTED BESS INTO TRANSMISSION NETWORK

Ensuring grid operational reliability with multi-frequency stability & resonance-interaction analysis

The challenge of integrating grid-connected BESS

Integrating grid-connected Battery Energy Storage Systems (BESS) into the power grid creates exciting opportunities to improve network stability, while also presenting diverse challenges. One significant concern is control interaction-based instabilities, which can occur at both sub-synchronous and super-synchronous frequencies, reaching up to several kilohertz. To address this challenge, Transmission System Operators (TSOs) often require a comprehensive multi-frequency stability study during the implementation phase of grid-connected BESS projects.

PTI Consulting supports you in ensuring that the combined system - comprising the transmission grid and the BESS - remains stable across a range of operating conditions and scenarios.

Key assessment methods

To successfully evaluate multi-frequency stability associated with grid-connected BESS, the scope generally includes following studies (Fig. 1):

- Impedance-based stability assessment
- Small-signal stability assessment in EMT Time Domain
- Large-signal stability assessment in EMT Time Domain

Impedance-based stability assessment

Impedance-based stability assessment is a method used to evaluate the stability of a power network when integrating a converter-based system. This approach involves calculating the frequency-dependent impedance of both the network and the BESS. At the coupling point, the AC grid and the BESS are modeled as Thevenin and Norton equivalents, respectively.

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It is assumed that both the grid and the BESS are stable on their own. However, instability can arise if the impedance angles of the two subsystems differ by 180°, which is analyzed using the Nyquist criterion. Stability margins, including phase and gain margins, are calculated to determine stable conditions.
TSOs typically provide frequency-dependent impedances of the AC network for various configurations.

Meanwhile, the impedances of the BESS plant are calculated for different operating points and control modes under evaluation. To derive the frequency-dependent impedance of the BESS plant, it is set up with an ideal voltage source superimposed with perturbation signals, and the frequency response is measured. Accurate models of the BESS inverters are essential for precise impedance calculations.

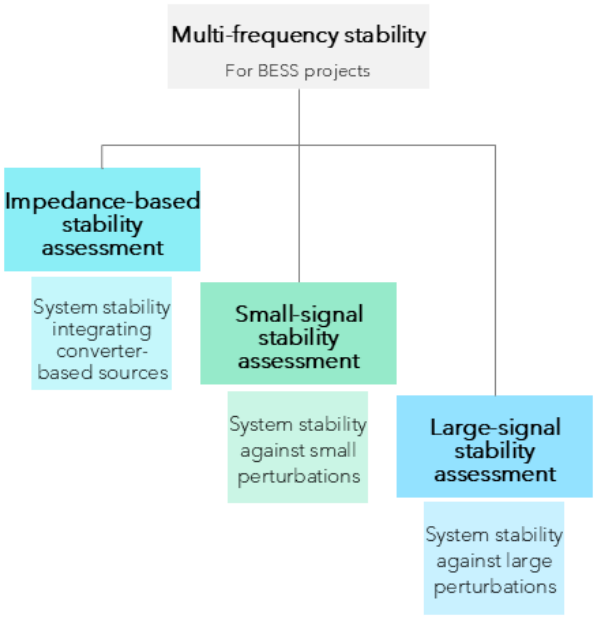

Figure 1. Multi-frequency stability studies

Time domain small-signal stability assessment

A comprehensive time domain study is performed using PSCAD/EMTDC software, which includes modeling BESS units with all their control loops and settings, as well as the upstream transmission network. Before conducting the dynamic stability assessment, steady-state network conditions are established through simulations using grid network models in either PSS/E or PowerFactory software. To assess system stability against small perturbations, a small-signal stability study is carried out in the time domain. This study considers the non-linearities present in controllers and power system components. It evaluates system oscillatory modes, damping, and overall stability, thereby validating the findings from impedance-based stability assessments. The simulations involve various perturbations such as load changes, generation changes, circuit tripping, and setpoint adjustments across different critical network conditions and BESS operating modes. The primary focus is on the critical cases identified in the impedance-based stability assessment.

Time domain large-signal stability assessment

Assessing time domain stability against large disturbances involves conducting a large-signal stability study in the Electromagnetic Transients (EMT) domain. Conducting this study ensures the evaluation of the dynamic behavior of BESS units and identifies potential unstable conditions within the network. The focus lies on assessing oscillatory modes, damping, ride-through performance, and overall stability in terms of frequency, voltage, and angle.

The simulations for this assessment include large perturbations such as symmetrical and asymmetrical faults near BESS units, significant load rejections, and the isolation of large generating units. By analyzing these scenarios, the integrated system can withstand and remain stable against large disturbances, maintaining reliable operation under various challenging conditions.

Your benefits

Comprehensive Stability Assessments: PTI Consulting assures system stability and performance across various operating conditions and control modes, ensuring seamless integration of grid-connected BESS into the transmission network.

Regulatory Compliance: You can trust our adherence to all relevant TSO requirements for multi-frequency stability and resonance interaction assessments.

Fast Turnaround: Benefit from an optimized delivery timeline ensured by a high-speed in-house simulation setup for time-intensive EMT simulations.

Dedicated Support: Use the convenience of a single point of contact for all types of power system studies.

Expert Consultancy Services: Benefit from our extensive range of long-term technical expert consultancy services.

Want to learn more?

Contact us

We are looking forward to giving you more information and answering your questions:
Via email to: pti.consulting.si@siemens.com
Via our contact form: PTI consulting
(Please add a short note that you are interested in BESS)

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