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Data-driven continuous-time framework for frequency-constrained unit commitment

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Abstract-

The conventional approach to solving the unit commitment problem involves discrete intervals at an hourly scale, particularly when integrating frequency dynamics to formulate a frequency-constrained unit commitment. To overcome this limitation, a novel continuous-time frequency-constrained unit commitment framework is proposed in this paper. In this approach, Bernstein polynomials represent continuous variables in the unit commitment problem and enable the calculation of frequency response-related metrics such as the rate of change of frequency, quasi-steady-state frequency, and frequency nadir, and the corresponding continuous-time constraints are introduced. Notably, startup and shut-down trajectories are meticulously considered, transforming the formulation into a fully continuous-time model and simplifying constraints related to variable continuity. To address the complexities associated with integrating the obtained non-linear frequency nadir constraint into a mixed-integer linear problem, an alternative data-driven frequency nadir constraint is proposed, which accurately constrains frequency nadir deviations throughout the time interval. To validate the proposed model, it is applied to the real-life network of the Spanish Island of La Palma. The data-driven method for estimating frequency nadir has demonstrated a minimum accuracy of 99.61% and has consistently maintained the frequency above the defined threshold.

Index Terms- Frequency-constrained unit commitment; Continuous-time formulation; Data-driven frequency nadir; Start-up and shut-down trajectories; Bernstein polynomials

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