Adaptive Dynamic State Estimation in Power Systems With Real-Time Y-Bus Matrix Estimation: A Step Toward Greater Practicality

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Dynamic State Estimation (DSE) has become pivotal in power system regulation and real-time contingency analysis, thanks to advancements in Phasor Measurement Units (PMUs) and Wide-Area Measurement Systems (WAMS). Traditionally, DSE relies on accurate, up-to-date information regarding system topology and loads. Maintaining precise estimations of these dynamic parameters is challenging and crucial for effective control and protection actions within power grids. This paper addresses the limitations of traditional DSE methods by relaxing the assumption that the admittance (i.e., Y-bus) matrix must be provided as an input at every time step. Instead, an adaptive variable forgetting-factor Recursive Least Squares (RLS) estimator is proposed for real-time Y-bus matrix estimation. This innovative approach leverages the inverse power flow equations to dynamically estimate the reduced Y-bus while simultaneously performing state estimation. To enhance accuracy and responsiveness, the estimator is integrated with the Gauss-Newton Variable Forgetting Factor (GN-VFF), allowing for precise adjustments and efficient tracking of changes. Implemented within a batch-mode regression-based Extended Kalman Filter (EKF), the GN-VFF-enhanced Y-bus estimator bridges the gap between theoretical assumptions and practical implementation. The effectiveness of this approach is validated through various scenarios on the IEEE 14-bus test system, demonstrating its potential to improve the practicality and performance of DSE in power systems.

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