Real-Time Adaptive Virtual Inertia and Damping Control Using MPC with Experimental Results for Industrial Microgrids with High Renewable Penetration

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Abstract:

This paper introduces a new Real-Time Adaptive Virtual Inertia Control (VIC) strategy designed to improve frequency stability in low-inertia microgrids. Our approach combines Model Predictive Control with automatic tuning via Particle Swarm Optimization, allowing the system to adjust itself on the fly. Through both simulations and experiments—including Hardware-in-the-Loop testing—we demonstrated that this method outperforms traditional controls by significantly reducing frequency fluctuations and errors, even when inertia and load conditions change. What's more, this adaptive control operates in real time without requiring any manual tuning, making it a practical and reliable solution for keeping renewable-heavy microgrids stable and resilient.