Advanced Event-Triggered and Time-Scale Decomposition Approaches for Microgrid Optimization Control

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Abstract. This research investigates an advanced control strategy for microgrids that integrates event-triggered control with time-scale decomposition techniques. The approach aims to address the challenges of coordinating control actions across multiple time horizons in a dynamic microgrid environment. By leveraging event-triggered updates, the control system can respond to significant changes while minimizing unnecessary computations. The proposed methodology is tested under various conditions, showcasing improvements in energy management, stability, and robustness compared to conventional strategies.

Keywords: Event-Triggered Control, Time-Scale Decomposition, Microgrid Stability, Distributed Control, Adaptive Systems, Optimization

Introduction:

The complexity of microgrids lies in their diverse components and the varying time scales over which these components operate. Efficient management of distributed energy resources (DERs), energy storage systems, and loads is critical for ensuring reliable and cost-effective microgrid operation. The challenge is further exacerbated by the variability of renewable energy sources and fluctuating load demands, necessitating control strategies that are both responsive and computationally efficient.

Traditional control frameworks often rely on continuous monitoring and periodic updates across all time scales, which can lead to excessive computational demands and delayed responses. To address this, event-triggered control techniques have been introduced, allowing control actions to be initiated only when significant deviations or events occur. When combined with time-scale decomposition methods, which break down control tasks into distinct temporal layers, a more efficient and adaptive control architecture can be realized.

This paper explores the integration of event-triggered control with time-scale decomposition in microgrids, focusing on the coordination of fast, medium, and slow dynamics for optimized energy management. The proposed control framework is validated through detailed simulation studies that illustrate its ability to maintain stability and efficiency even under rapidly changing conditions. The results demonstrate a substantial improvement in both operational performance and computational resource allocation.