Multi-Time Scale and Event-Triggered Optimization Control Strategies for Microgrids

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Abstract. The increasing integration of distributed energy resources (DERs) and renewable energy into microgrids presents challenges in maintaining system stability and efficient energy distribution. This paper explores a multi-time scale optimization control framework combined with event-triggered mechanisms to enhance the operational performance of microgrids. By coordinating control actions across different time scales—ranging from real-time operations to long-term planning—while implementing event-triggered adjustments, the proposed approach ensures optimal control and stability in dynamic conditions. The effectiveness of the approach is demonstrated through simulation results, highlighting its adaptability and improved efficiency compared to traditional methods.

Keywords: Microgrid, Multi-Time Scale Control, Event-Triggered Control, Distributed Energy Resources, Optimization Control, Adaptive Systems

Introduction:

The growing interest in sustainable energy has accelerated the deployment of microgrids, small-scale power systems capable of operating autonomously or in conjunction with larger grids. A microgrid's complexity arises from its reliance on distributed energy resources (DERs) such as solar panels, wind turbines, and energy storage systems, which are inherently variable and uncertain. Traditional control strategies often struggle to address the dynamic and multi-layered nature of microgrid operations, especially when considering the wide range of time scales at which decisions need to be made—from real-time adjustments to long-term optimization.

To overcome these challenges, there has been a shift toward more sophisticated control strategies that incorporate multi-time scale frameworks and event-triggered control mechanisms. A multi-time scale approach allows the coordination of control actions across various time horizons, ensuring that both fast dynamics and slower system-level decisions are managed efficiently. Simultaneously, event-triggered control reduces unnecessary computations and control actions by only updating control signals when certain conditions or thresholds are met.

This paper presents an integrated control strategy for microgrids that combines multi-time scale optimization with event-triggered mechanisms. The goal is to achieve a robust, adaptive control system that enhances both the stability and efficiency of microgrid operations under varying conditions. The proposed approach is validated through detailed simulations that demonstrate its superiority over conventional methods in terms of both performance and computational efficiency.