

# Title: Flywheel Energy Storage Systems Utilization for Short-Duration Power System Frequency Stability Support

**Abstract:** The transition to decentralized and inverter-based resources in the power system has led to a significant reduction in system inertia, which in traditional systems is used for inertia support, making frequency stability a critical operational challenge. Flywheel Energy Storage Systems (FESS) offer a promising solution for short-duration frequency support due to their rapid response time, high power density, and long cycle life compared to similarly sized Battery Energy Storage Systems (BESS). This paper investigates the use of FESS to enhance power system frequency stability during transient disturbances and load-generation imbalances. The study emphasizes the dynamic behavior of FESS in delivering synthetic inertia and primary frequency regulation within milliseconds. Various control strategies, including virtual synchronous generator (VSG) control, frequency-droop characteristics, and coordinated control with other storage systems, are reviewed and evaluated. Simulation-based analyses are presented to demonstrate the effectiveness of FESS-based DC machines in limiting frequency deviations, improving the rate of change of frequency (RoCoF), and supporting system recovery. The findings underscore the suitability of FESS for short-duration, high-power applications in power systems. Future research directions are proposed to address optimization in sizing, integration with hybrid systems, and advanced control for improved frequency resilience.

**Keywords:** Flywheel, Short-duration, Low-inertia