MODULAR FLYWHEEL ENERGY STORAGE SYSTEM

Background

Fast, efficient and safe energy storage is indispensable for a sustainable future. The state of the art mechanical energy storage systems with flywheels have many advantages such as high specific power capacity (charge/discharge rates), thermal stability, decoupled energy and power capacity, and large number of life cycles. Therefore, these systems can be integrated in applications with intermittent energy sources (renewables) and in quick charge/discharge scenarios. However, on the downside, they lack safety and reliability due to the possibility of a sudden failure of the rotor and the release of the entire stored energy.

Mechanical batteries or flywheel energy storage systems (FESS), can be designed to circumvent the aforementioned disadvantages and operate with high efficiency at the expense of specific capacity by operating at reduced speeds. Figure 1 shows a typical FESS connected to a local grid. The current FESS consists of one flywheel rotor operating at sub-critical speeds using either permanent magnet or synchronous reluctance motors. Many such large and expensive flywheel units are cascaded to form a large capacity storage system where, failures are prominent due to imperfections in the system components. Moreover, there are separate inverters and control units to control each flywheel unit, which incurs its own losses. One possible solution is to design a compact and modular FESS system where, multiple small flywheel units operating synchronously at ultra-high speeds are connected in a desired pattern to form modules. Thereby, the reliability and safety of the overall system are not compromised, but are improved multiple folds, while not losing the edge of this technology.

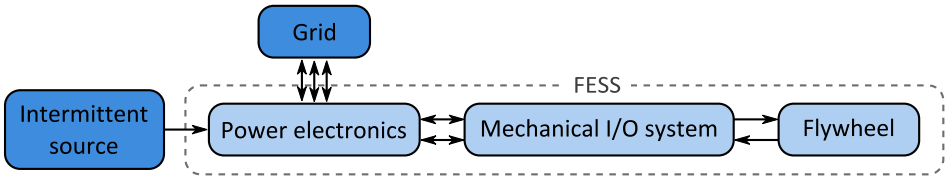

Figure 1: A typical scenario of a flywheel energy storage system connected to a local grid. I/O implies Input and Output.

Description

This assignment focusses on the collective control of multiple ultra-high speed electromechanical machines. The objective is to establish a control scheme to operate as many permanent magnet synchronous motors connected in series-parallel arrangement at a certain speed (around 500 krpm, typically 120 W each) with minimal number of inverters.

Approach

A preliminary approach in achieving the objective is as follows:

- Perform a literature survey to get familiar with the topics and establish the necessary parameters to control multi- motor/generator systems in series-parallel arrangement.
- Perform an assessment to answer: is a collective/synchronized control effective or cost efficient than an individual control per flywheel unit? Suggest ideas to improve the state-of-the art.
- Propose a concept design for the control system and the necessary data to be acquired from the electrical machine and/or the inverter for effective control.
- Perform fundamental calculations and/or simulations to evaluate the basic design parameters so as to arrive at the desired arrangement of the modular flywheel system which can deliver/absorb a certain amount of power in a given time.
- Manufacture a prototype system with 2-Series-2-Parallel flywheel arrangement and experimentally establish the performance parameters of the controller.
- Finalize the design and analysis of the collective control system with a thesis.

Administration and contact person

This assignment will be executed within the group of Applied mechanics. We need motivated masters student(s) to obtain valuable results in around 8 months' time and graduate with flying colors.

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