Large Buffer Storage

CONTEXT

The massive introduction of remote power electronics interfaced renewable generation units and high-voltage direct current (HVDC) interconnectors into the existing power system, with the aim of decommissioning a part of conventional centralized generation, has introduced new challenges to grid operators to maintain system stability. Since conventional balancing services rely on the availability of traditional synchronous generators and the kinetic energy stored in their rotating masses, new methods for providing ancillary services must be introduced.

TECHNOLOGY DESCRIPTION

MMC stores energy in its distributed sub-modules and this energy can be controlled. This is a degree of freedom that can be utilized to supply ancillary services. However, one of the major drawbacks is the limited amount of energy available, which is considerably smaller than a typical AC power plant. Nevertheless, the energy stored inside the MMC can be increased with the help of energy storage systems (ESSs). This study is related to the integration of ESSs within MMC submodules (SM) in order to provide ancillary services (mostly fast frequency response (FFR)).

Introduction of the ESS into all SMs as well as only in the selected number of SMs within MMC have been studied. The analysis dealt with the internal energy exchange to maintain the proper function of the converter by using circulating currents. This study helps to design embedded ES-SMs in the converter to provide new functions like ancillary services for power system operation.

A modular DC-DC converter (Patent Application) has been proposed as an interface between the energy storage element and the SM capacitor. It has been shown that the volume of the passive components can be reduced in comparison with interface converters known in the literature. The proposed control method provides an appropriate energy exchange without affecting the control philosophy of an MMC and it addresses balancing issues. Simulations and a downscaled prototype confirm the relevance of the proposed control.

In this work, supercapacitors are used as ESS. Ageing studies have been performed to assess different levels of redundancy and maintenance required to achieve expected performance over lifetime of the converter.

APPLICATION DOMAIN

- HVDC and FACTS
- Grid Ancillary Services
- Submodule Technology

ADVANTAGES

Compact solution is proposed for MMC converter to provide Fast Frequency Response service to AC grid based on supercapacitor ESS.

Comprehensive study of integrating ESS within MMC submodules and location of these submodules within MMC.

TRL SCALE

DELIVERABLES

PhD Thesis
Simulation models in MATLAB/Simulink
Energy Storage Design Tools
PATENT WO2020225332A1
PCB Prototype
Storage Element Ageing Characteristics

SCIENTIFIC REFERENCE

Florian Errigo, Florent Morel, Cedric Mathieu De Vienne, Laurent Chédot, Ali Sari, and Pascal Venet, “A Submodule with Integrated Supercapacitors for HVDC-MMC providing Fast Frequency Response”, IEEE transactions on Power Delivery.