Cascaded Multilevel Converter with Floating Capacitors for a small tokamak, PHiX

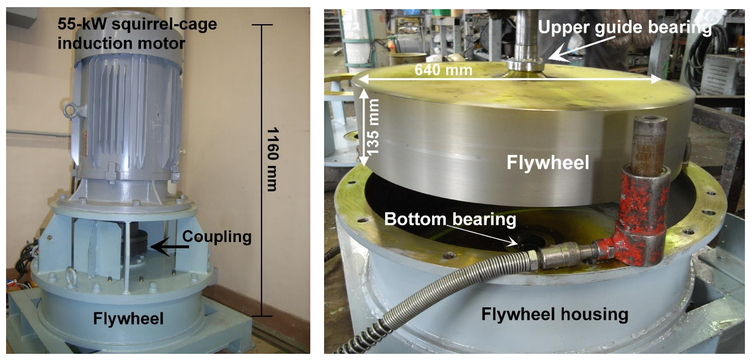
Masamichi Murayama†, Shuhei Kato††, Hiroaki Tsutsui†, Shunji Tsuji-Iio† and Ryuichi Shimada†

†Tokyo Institute of Technology, Tokyo, Japan †† Nihon University, Chiba, Japan

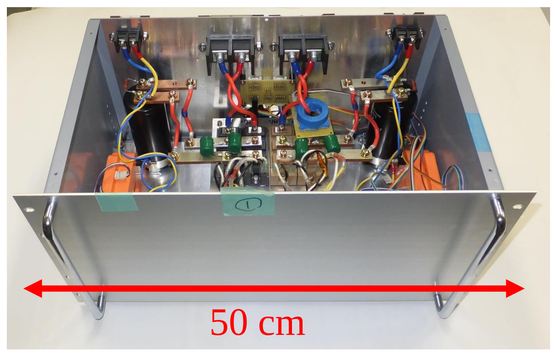
Mon-Af-Po1.12-08

1. Introduction

In tokamak devices, there are many coils that require rapid response to control plasma position and to induce the plasma current. The plasma moves and touches the vacuum vessel **within 1 ms** in small devices. We have to control the poloidal field (PF) coil currents that can pull and push plasma to avoid the collision. We also have to increase the poloidal field coil current quickly to build up the plasma current and start up tokamak devices. Furthermore, normal conducting coils require a mount of power consumption.



Prototype of flywheel energy storage system. The squirrel-cage induction machine is connected to the iron flywheel by a coupling.



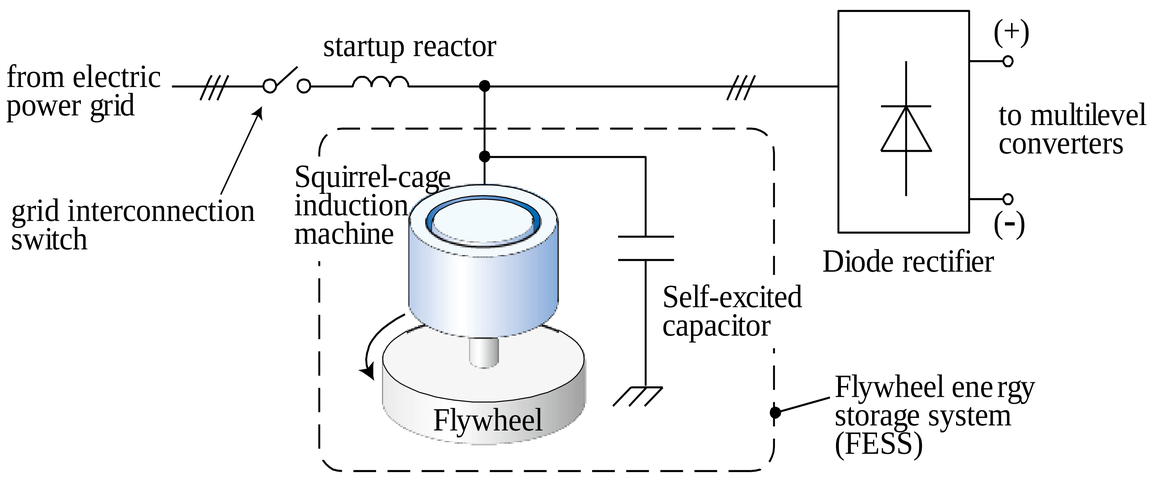
Converters used for the experiment. Two H-bridges are installed in the box and the output terminals are connected in series.

Objectives

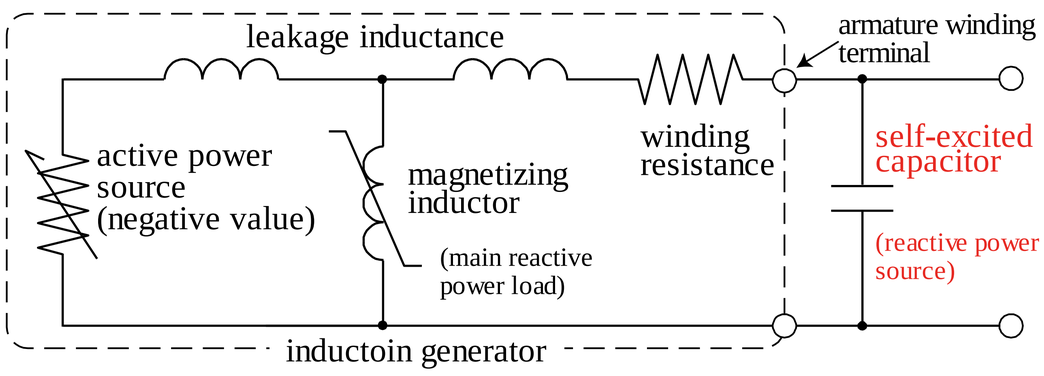
- Increasing in the current response speed of the power supply system.
- Supplying pulsed power to the system in order to suppress the disturbance to power grids.

2. Circuit and Control Method

Power compensation for pulsed power consumption in load

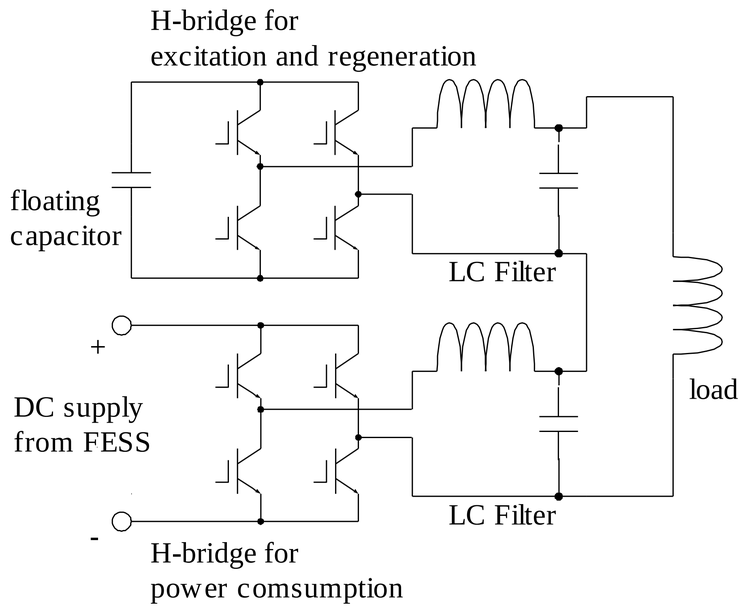


Proposed system configuration of pulsed magnet power supply by the SEIG with Flywheel. This system consists of grid interconnection switch, starting reactor, induction machine with flywheel, diode rectifier.

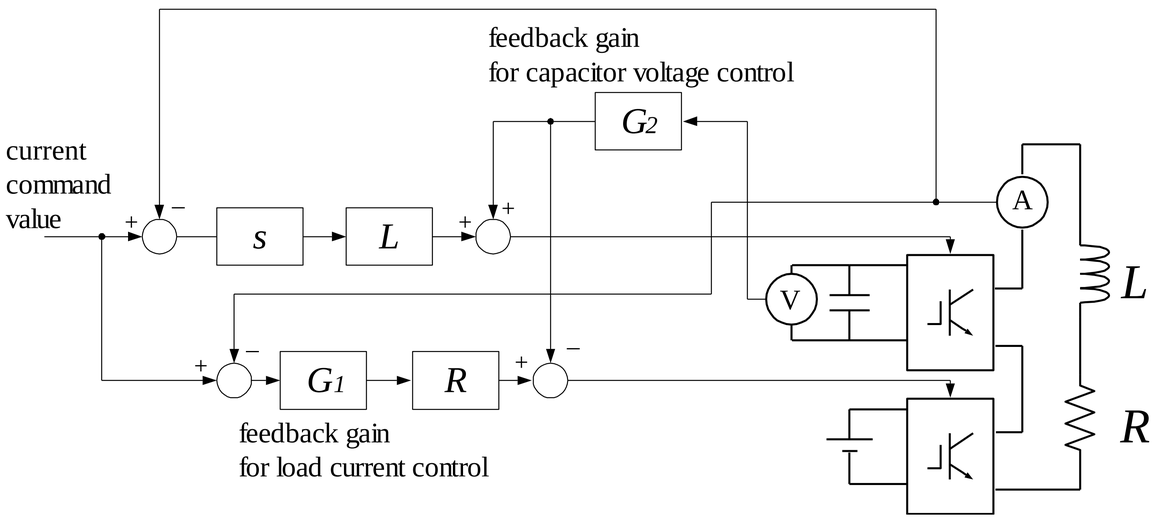


Equivalent circuit of a self-excited induction generator. A self-excited capacitor is necessary as a reactive power source to be supplied to magnetizing inductor.

Voltage boosting using MMCC to excite inductive load

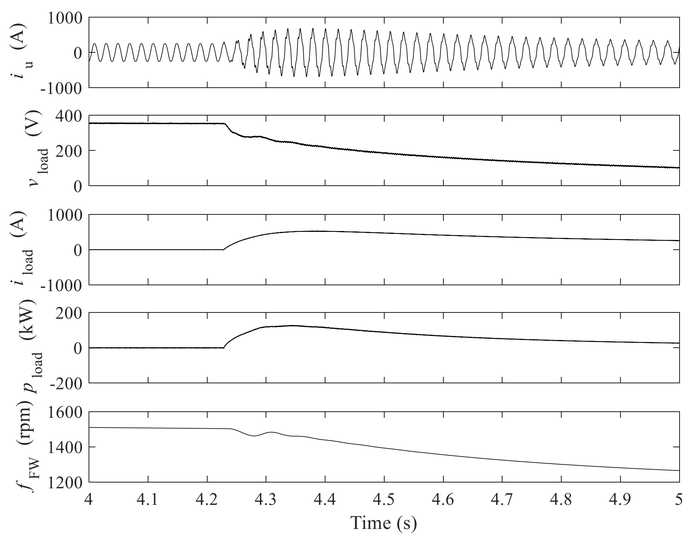


Proposed configuration of modular multilevel cascade converter. This system consists of H-bridge converters, a floating capacitor and LC filters. One converter is supplied from FESS and the other is connected to a floating capacitor.



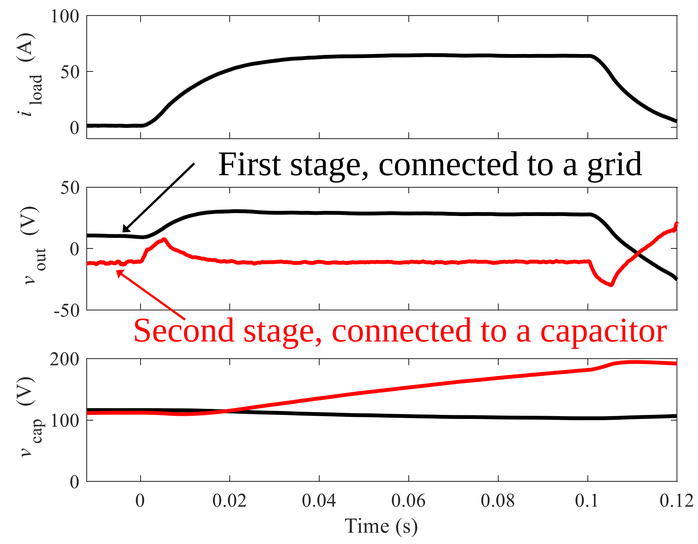
Block Diagram showing the proposed control method of the modular multilevel cascade converter. There are three feedback loops for P control, D control and capacitor voltage control.

3. Experiment



The figure shows that the generator fed electric power to the load immediately. the peak power was **140 kW** and the generator can supply 110 kW or **twice of rated power for 0.1 seconds**. The operation stopped due to the lowering of the flywheel revolution.

The figure shows the operation of the boosting modular multilevel cascade converter. Initial voltage of the floating capacitor was charge up to 100 V through the load coils.



The converter was commanded to output constant current through out the operation. The **converter with a floating capacitor output positive voltage** and **boosted the current at the start** of the operation because its reference is calculated by derivative of load current.