PHD THESIS

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Frequency converter solutions and control methods for variable speed operation of pump storage plant

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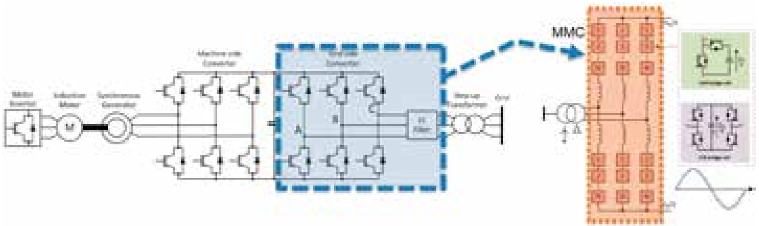
Background

At present, the pump storage hydropower plants are realized with at a ternary set of turbine, AC machine (generator/motor) and pump connected on the same shaft. The combination of turbine and AC machine (as generator) are active in power generation mode whereas the AC machine (as motor) and pump set are active in pumping mode. As the AC machines are directly connected to the large AC network, the ternary set of machines run at almost constant speed depending upon the frequency of the grid regardless of the amount of water flow into the turbine/pump. However, it is a well-proven theory that the turbine/pump operates at optimal efficiency only if its speed is varied according the variation in the water flow. This optimal efficiency operation of hydraulic machines can be achieved only by decoupling the turbine/generator sets from the AC grid using a full power back-to-back converter between the AC machine and the grid.

The research within this PhD will involve a lab setup of 100 kW capacity with 2-level back-to-back converter connected between the grid and the synchronous machine. The prime mover of the synchronous machine will be an induction machine and the variable speed operation of turbine to track the maximum efficiency will be simulated using a motor inverter connected to the induction machine. As the converters decouple the physical inertia of the machine, emulating virtual inertia and damping in the control system will be also be one of the major requirement. The decoupling will also limit the influence of grid dynamics on the hydraulic and civil structures.

To avoid the additional passive filter components or to make it very small, Multi-Modular Converter (MMC) topologies will also be tested.



Lab set-up (future extension in orange color)