Study Committee A1

Rotating Machines

Paper A1_10863_2022

Fundamental model of full power converter variable speed Hydro Generators: Control and Simulation

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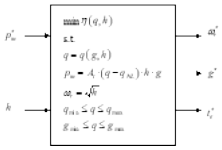
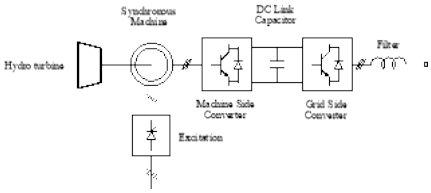
Motivation

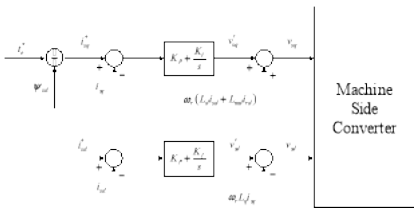
- Speed control of large hydro generators has become feasible due to the development of high power electronics.
- Hence, hydro generators can run at the maximum efficiency operating point with respect to the output power and head.
- The application of speed control in pumped storage hydro generators is especially advantageous
- Speed control of hydro generators can be implemented controlling either a doubly fed induction machine or a synchronous machine connected to the grid through a full power converter.
- In case of a synchronous machine connected to the grid through a full power converter to the grid, the converter is made up of two voltage source converters (the machine side converter and the grid side converter) with pulse width modulation coupled through a DC link capacitor. The hydro turbine is equipped with a speed governor. A unit controller coordinates the control of the synchronous machine and the hydro turbine.
- This paper details a fundamental model a full power converter variable speed hydro generator. The model is aimed at investigating interactions between synchronous machine and turbine controls.



Unit controller



Variable speed synchronous machine

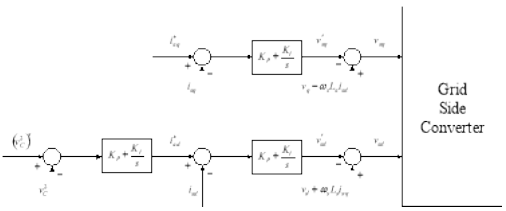


Machine side converter controls

Model

The model comprises

- The unit controller
- The model of the synchronous machine, the AC/DC-DC/AC voltage source converters and the machine and grid side converter controls
- The model of the penstock, the turbine and the governor



Grid side converter controls

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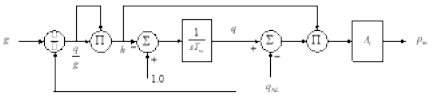
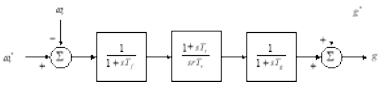
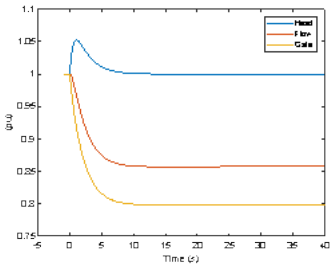


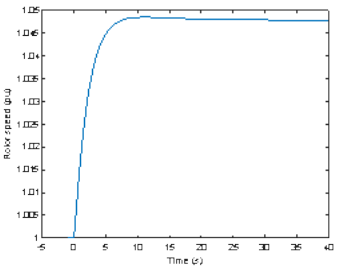
Penstock and turbine



Governor



Head, flow and gate

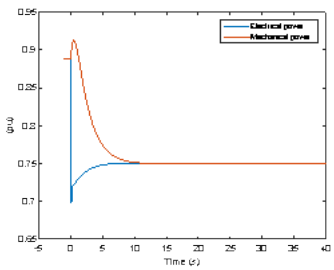


Spped

Simulation results

Response to a step of reference power

- It can be seen the very fast response of the electrical power as governed by the full power converter. The response of the mechanical power is slower. Of course mechanical power is identical to the electrical power at the end of the transient. The mechanical power exhibits at the beginning of the transient the characteristic inverse response of the hydro turbine: the mechanical power increases
- The head exhibits a upward transient coming back to the original steady-state. Flow and gate reduces to reduce the ouput of mechanical power
- The rotor speed increases to reach the maximum efficiency corresponding the desired electrical power output. The PI regulator provides a smoth transient response



Electrical and mechanical powers

Conclusions

- The variation of the electrical power results to be very fast due to the control of the full power converter.
- Turbine variables exhibit smooth and slower response pattern without any adverse interaction with the electrical variables.