Abstract

- Proportional-Integral-Derivative (PID) control is the most widely used governing methodology for hydroelectric turbine control.
- A fourth order lead-lag controller is used at the U.S. Bureau of Reclamation’s Grand Coulee Third Power Plant, one of the largest power producing facilities in the world.
- In constraining certain parameters, a range of PID controllers can be modeled and compared against the Lead-Lag algorithm, exposing performance similarities and differences.

Brief History

- Traditional/industrial controllers used by American Governor Company - Daniel Londono, Matthew Roberts, Paul Silva, and Reginald Smith

In 1990's the Bureau expanded and implemented a Double – Derivative control algorithm in the early 1990's for use on all their analog electric governors in the Three Power Plants. The advanced fourth order control algorithms compared for precise transients (i.e. speed deviations) that have the potential to affect the tuning of other algorithms.

- The fourth term requires advanced algorithms and monitoring of system characteristics during actual operation to properly implement.
- This controller requires advanced knowledge of the control algorithms involved and substantial resources to gather the information necessary for optimization.

Comparison of Lead-Lag vs. PID

- Lead-Lag and PID controllers are capable of achieving the same response under certain parameters. The following graphs show the mapping of each Lead-Lag controller term to the proportional and derivative gains of the PID controller.
- The PID controller with Setpoint Feedforward, as implemented by American Governor Company, is able to compensate for speed changes in a manner similar to the Lead-Lag controller.
- The Lead-Lag controller is capable of achieving true ramping, fast system response to transients, and derivative response to speed changes.
- The Lead-Lag controller is well suited to compensate for lower frequency and higher order transients. It also exhibits quick response during load transients.

Grand Coulee – Third Power Plant

- The Grand Coulee Dam was constructed between 1933 and 1941 on the Columbia River in Washington State. Originally outfitted with two power plants, Left and Right, totaling 2801 MW, a third and much larger power plant was constructed in 1941.
- With an installed capacity of 6,809 MW, the Grand Coulee project is the largest power complex in North America.

American Governor Company implemented the Lead-Lag control scheme in its comprehensive retrofit project, begun in 2010.