Hydro Control Solutions

A Petrotech, Inc. White Paper

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Company Overview

Petrotech Incorporated (Petrotech), headquartered in New Orleans, Louisiana has been providing advanced turbomachinery and process control systems for more than 40 years. With facilities in Houston, Texas and Suffolk, United Kingdom, Petrotech provides a full range of products and services for rotating machinery control and instrumentation. Our products include integrated control systems for gas, hydro and steam turbines, generators, compressors, pumps, and their associated ancillary systems. We also provide sophisticated process control solutions around the rotating machinery that complement or replace DCS based plant controls. Our turnkey services include engineering design (software and hardware), control panel manufacturing, site I&E services, commissioning and startup.

Our automation solutions help our customers increase reliability, improve efficiency, and reduce downtime. Over our 40 years, we have developed a library of mature control products and applications. These applications have logged millions of hours controlling, optimizing, and protecting the operation of a variety of rotating machinery.

Regardless of where in the energy chain Petrotech operates, our approach remains the same. To deliver superior customer satisfaction, that builds upon our reputation as a leader in rotating machinery controls.

Abstract

In Run-of-River hydropower operations, the River's natural flow is used to produce electricity via the hydro-electric turbine. The ability to effectively and reliably control the hydro-electric turbine depends largely on the performance of the turbine governing system. The primary function of the hydro-turbine governor or regulator system (Hydro_TR) in run-of-river hydro operation is to smoothly pass the water flowing through the turbine(s) back to the river while keeping the reservoir level within regulatory compliance limits and optimizing generation. The Hydro_TR system ultimately provides a demand signal to control the position of the hydro-turbine wicket gates which in turns modulate the water flow.

Other major functions of the Hydro_TR include start-up and shutdown control, isochronous/droop speed control, power limiting control, flow control (re-regulation), pump control, and coordination control of multiple units. Protection functions such as overspeed, step change, temperature, and condition monitoring are also part of the Hydro_TR scope.

This paper describes Petrotech's core Hydro_TR solution for Run-of-River Systems, highlighting its flexible and scalable features. The Hydro_TR is designed to be a solution platform that is highly adaptable to meet the needs of any Run-of-River governing system.
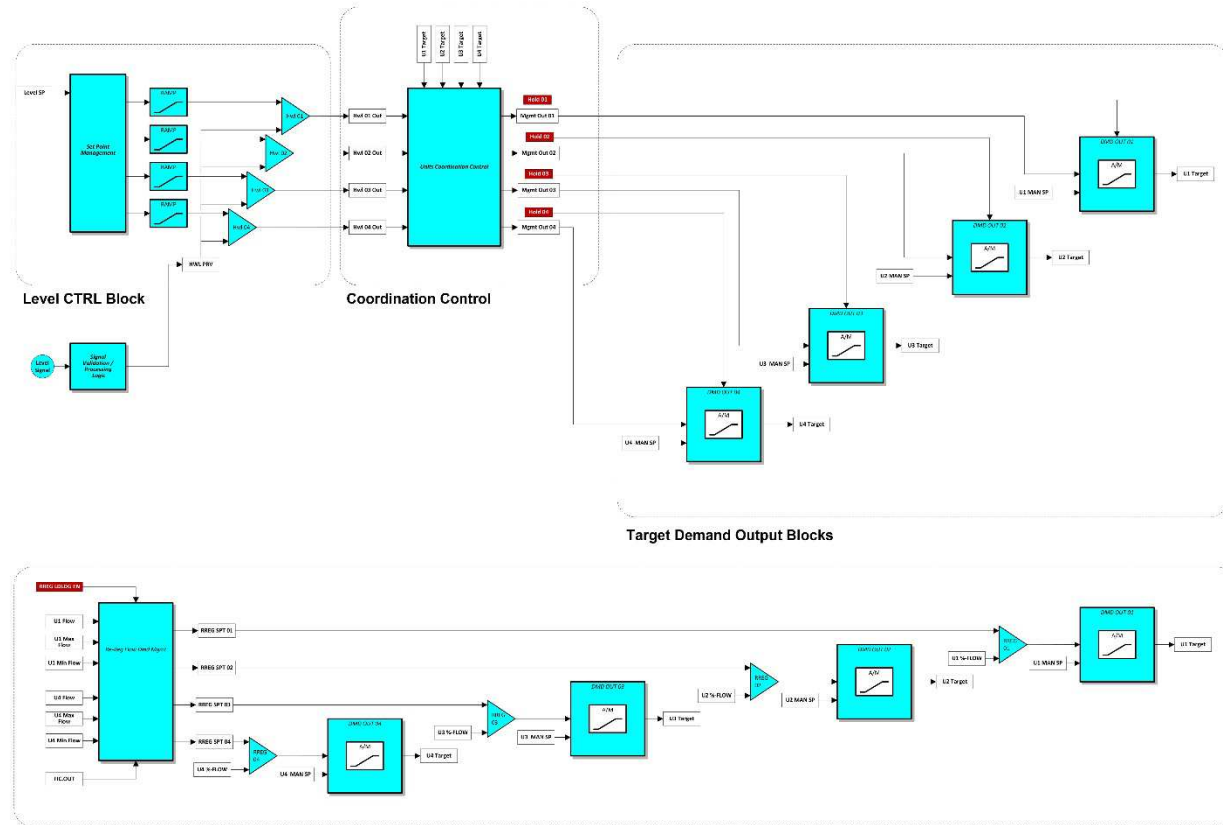
Run of River Hydro Control

Run-of-River control systems are characterized by relatively small "impoundment" or storage of the water, thus minimizing impact to the natural river flow. In Run-of-River systems, river water is diverted to a channel or reservoir. The water is then "dropped" into a pipeline known as the penstock that delivers the water to the power plant housing the hydro turbine(s). The moving water rotates the turbine which spins a shaft connected to a generator to produce electricity. The water that passes through the turbine(s) is returned to the river.
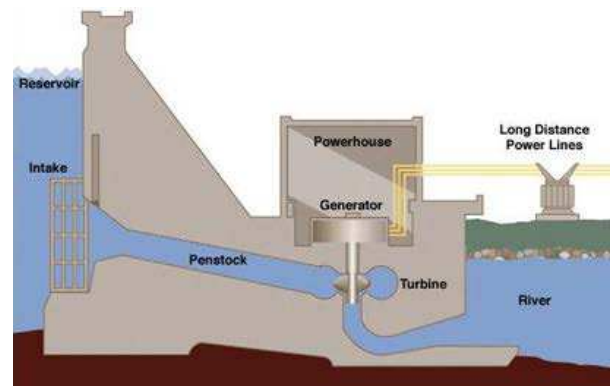
Hydro-Turbine Power Generation

Petrotech Hydro_TR system is built upon proven subsystems that reflect our 40+ years expertise in turbine applications and process know-how. These subsystems are designed to cover virtually all hydro turbine governing requirements for run-of-river systems. The Hydro_TR system is designed to provide a high degree of flexibility and scalability. Thus ensuring reliable control and monitoring of hydro governing operations.

Our Hydro_TR solutions are scalable from a single turbine generator system, to a multi-unit power house, to cascaded hydro plants or to the entire generating fleet.

Target Demand Output Blocks

Run of River Control Algorithms

**Petrotech Run-of-River Control Algorithm**

The Run-of-River Hydro_TR monitors key hydro-operation process parameters (i.e. head/tail water level, flow, power), along with turbine specific signals (i.e. speed, gate position) and applies a selected control algorithm to determine the position demand for the turbine wicket gates to regulate water flow through the turbine. Required process and turbine signals are conditioned (i.e. validation, averaging, step detection and selection) using functions executed in the Hydro_TR prior to application of the control algorithm.

The Hydro_TR includes a set of control algorithms configured in various combinations to achieve the Run-of-River control objective of maintaining reservoir level within licensing limits while optimizing generation and smoothly regulating the flow back to the river.

The control strategy is easily configured and adapted as follows:

- PI controller(s) (for head/tail water level, flow or power control)

- PI controller(s) with anticipation feed-forward control

- PI controller(s) with predictor model

- Head/Tail water level controller(s) with cascaded re-regulation flow controller(s)

- Any combinations of the above

Extensive tuning parameters are available for our control algorithms to achieve control objectives.
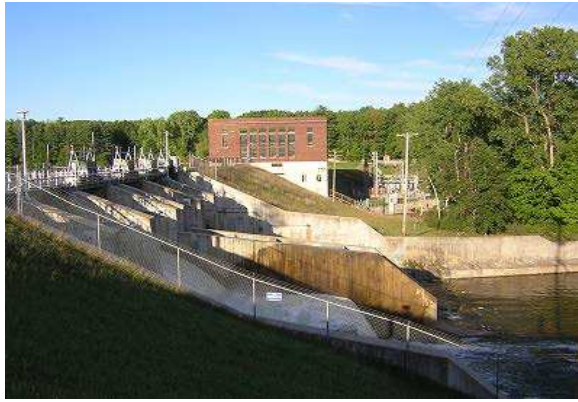
Run of River Hydro Plant

Other Control Features

Other features offered by the Hydro_TR include functions for optimizing generation (units operate at their most efficient gate position for existing river flow), and priority based or coordinated control of multiple units for efficient water resource management (i.e. setup units for load-sharing, scheduling priority usage of units at a single station or coordinating operations with other stations along the run of river, and water storage management).

Additional control modes available in our Hydro_TR solution include turbine automatic or manual start control, speed control, and manual control. Start control consists of a configurable demand ramp to perform a controlled unit breakaway and start until the unit achieves normal speed. Speed control is used when the unit is starting and has reached a valid start speed. It is implemented using a PID control architecture and is used in auto-start mode or when the unit is not configured to use level or flow control mode. Manual control mode enables the operator to enter a target position demand or use the increase/decrease discrete command to adjust the position demand.

Each control mode uses sets of configuration parameters. The parameters provide the flexibility to customize each mode to meet the control needs of specific run-of-river hydro applications.

Flexibility

Petrotech's Hydro_TR system offers a high degree of flexibility due to its modular structure design, extensive parameterization, and use of open system architecture composed of well-established control application components.

The system components are designed using a modular requirement approach such that the control solutions are easily deployed using only the components needed from our library of subsystems. Our field-proven control software routines, developed in standard IEC 6-1131 structured-text allow the applications to be easily ported across any IEC 6-1131 compliant controller platform. Thus when an upgrade or addition to the system is required, the components are seamlessly added.

Extensive configuration parameters are available on our governor control solutions, offering a wide range of control modes to meet the various demands of Run of River Hydropower applications without the need for additional programming. Thus solution can be adapted easily to provide a high degree of flexibility.

Open system architecture offers flexibility in terms of using well established industry standard components which simplify maintenance, serviceability and training. This results in reduced cost of ownership and provide client ability to use preferred platform. Open interfaces also provide flexibility to support easy integration with existing hydro plant systems.

Scalability

Our Hydro_TR solutions are specifically designed for open and distributed architecture platforms using a common design environment to provide the highest degree of scalability and reliability. System components are selected based on optimized performance and capability to easily expand from a single system to the entire fleet. The hydro control solutions are also designed to support system expansion in incremental fashion. As the system requirements grow, components (i.e. controllers, I/O, HMIs, Monitoring Stations and field devices) can be added without performance degradation. Future growth demand can be easily accommodated with our scalable solutions.

Petrotech Hydro_TR offers scalable options from stand-alone system consisting of cabinet containing standard open architecture components such as controllers, I/O, network interfaces and built-in HMI, to system integrated with plant control/monitoring center, to system providing coordinated control of multiple hydro stations along the run-of-river communicating via satellite or cellular networks.

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