Power Generation

Hydro power
Intelligent solutions for hydroelectric power plant controls

Power and productivity
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ABB

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ABB offers advanced control solutions for hydroelectric power plants. With experience on a global level and across a variety of plant configurations, you can be assured ABB's solutions will provide your plant with a highly integrated control scheme utilizing reliable, optimized, and proven practices. This brochure is an overview of many of the advanced applications ABB provides for your hydroelectric power plant.

Unit Control

ABB solutions comprise all the systems required to successfully automate a hydropower plant. These modular and scalable systems manage the automation of the units, plant auxiliaries, substation, regulation of basins and hydraulic works, as well as the speed/load control of the hydro turbines.

Whether it is for small hydro unit controls, run of the river hydro chain control or complex pumped storage applications, ABB solutions incorporate the following components and features:

- Unit control (turbine, generator, power transformer and unit auxiliaries)
- Plant control (common plant auxiliaries, HV switchyard, spillway, intake and other hydraulic systems)
- Complex control functions, such as joint control, cascade control, flood and river control, plant frequency control, reactive and active power control
- Remote control and dispatch center connectivity
- Integrated electrical and mechanical protection throughout the plant

Unit Control
- Automated start/stop sequences
- Interfaces to:
  - Metering
  - Protection
  - Mechanical balance of plant
  - Electrical balance of plant

Applications supported:
- Relay based
- PLC/DCS based - S+ and 800xA
- By communication IEC104
- RTU

Dispatch center control room
- Load dispatching
- AGC and Joint Control
- Voltage/VAR
- Load dispatching

Retrofits and upgrades
- Vintage hydraulic governors
- Standardization of operator interfaces
- Old to new type of turbines
- Modernization of plant monitoring

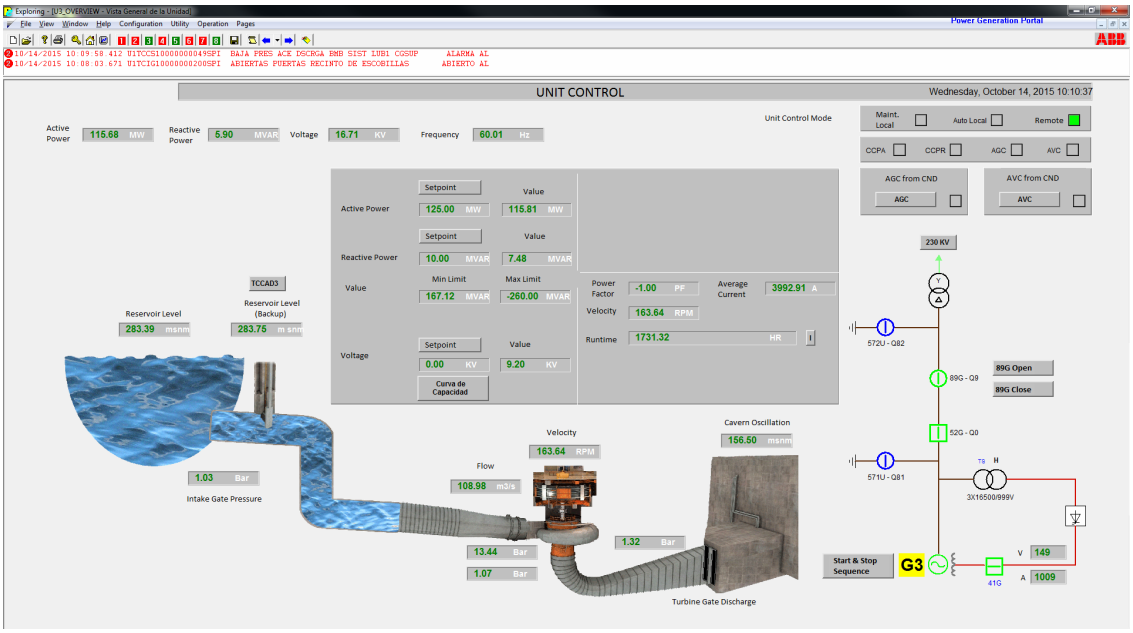

Figure 1. Unit Control operator display

Hydro power
Hydroelectric power plant Automatic Generation Control (AGC) overview

Automatic Generation Control (AGC) of generating units by governor control action is commonly referred to as Primary Frequency Regulation (PFR). The main objective of the governor is to maintain or attempt to return the frequency of the system to scheduled value as soon as an upset occurs. This is done using a proportional gain controller which is also referred to as droop control. Typically, governor droop control action can quickly recover a significant part of the frequency change, but cannot completely return the system to its nominal frequency alone. Eliminating the frequency deviation is therefore performed by what is known as the Secondary Frequency Regulation (SFR). The SFR is used to make up the difference in generation that is not covered by the governing system. This is achieved by increasing or decreasing the MW generation by way of unit MW setpoint or an entire plant MW setpoint when Joint Control (JC) is available. This is typically done by a dispatch center in which one of the main tasks is to correct for the long term frequency and generation schedules.

The AGC and JC portion of the station controls manages the selection, activation and supervision of the included joint operating modes for each of the units in a plant. Joint control is only applicable to plants with two or more units. The AGC applications provide the plant operator with full (or partial) station control via a single point of control. Hydroelectric power plants are extremely suitable for remote and unmanned operation. This is typically achieved with the use of JC of the active and reactive power functions described in this brochure.

Customized applications
- Run-of-the-river hydroelectric power plants
- Pumped storage facilities and volume control for environmentally sensitive plants
- Reservoir type hydroelectric power plants
- Regulating dam (see gate flow applications)
- Any size hydroelectric power plant, with any number or types of turbines
- Level control and flow control to maintain water supply and avoid environmental disruption
- Hydro-chain control to balance flow between plants
- River flow and level optimization
- Net head compensation
- Water usage optimization

Benefits
- A fully customized technical solution that addresses your challenges and environmental needs
- Improvements in efficiency to reduce water consumption, yet producing the same amount of energy
- Reduced risk by working with an experienced integration partner with a broad portfolio supported with a global footprint and local service

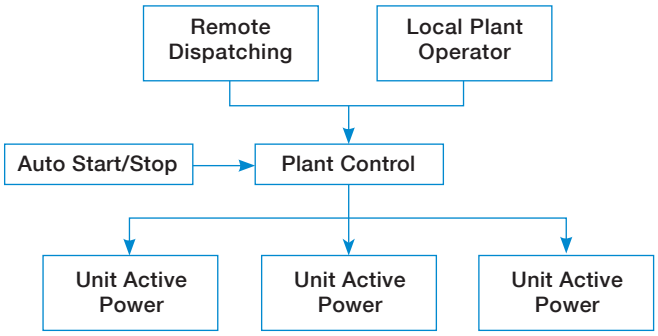

Figure 2. Typical control flowchart

Hydro power
Joint Control Active Power (JCAP)

Joint Control Active Power (JCAP) provides a plant the ability to receive a single MW generation setpoint that may be shared among a group of several turbine generators. The plant MW setpoint may be either modified at the plant itself, or from any pre-designated remote location. Generating units that desire to operate separately from the JCAP group may be selected to individual mode.

The **Individual Control Active Power (ICAP)** provides a setpoint that will be introduced by the operator HMI normally local to the plant. It is possible for the operator to combine any turbine/generator associated to the joint control operation mode i.e. JCAP, or ICAP mode at any time. See Figure 3, Typical Joint Control Active Power flowchart.

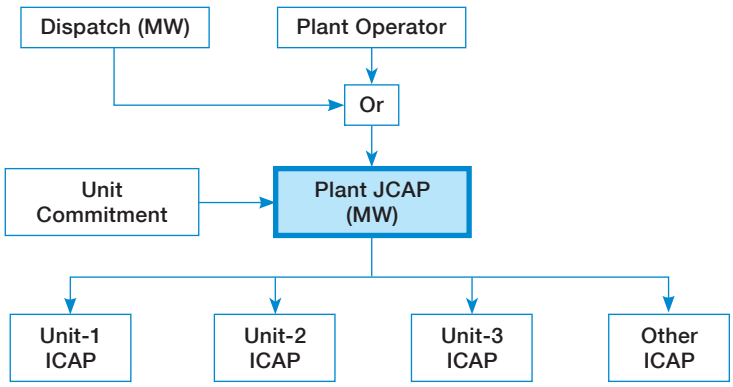

Figure 3. Typical Joint Control Active Power flowchart

JCAP functionality

Cost effective active power control features includes:

- Dispatch center communication data-link
- Dispatch center generation MW setpoint
- Plant generation MW setpoint
- Unit commitment (plant auto start/stop)
- Unit priority (operator selected, or run time hours)
- Plant optimization (economic dispatch)
- Daily generation schedules
- Frequency control
- Automatic Time Error Correction (ATEC)
- Communication with governing system
- Spinning reserve margin control
- Spinning reserve monitoring
- Plant efficiency calculations (optional)
- Plant net head and losses calculations (optional)
- MW ramp management
- Turbine rough zone management

Hydro power
Joint Control Reactive Power (JCRP)

Joint Control Reactive Power (JCRP) logic is used to control the total reactive power production/absorption of the power plant. The setpoint is entered as a reactive power value (Mvar), or in KV when voltage control. When the operator makes a JCRP setpoint change, the Mvar of each unit in JC is moved simultaneously and in parallel.

Generating units that are desired to operate separately from the JCRP group may be selected to individual mode.

The **Individual Control Reactive Power (ICRP)** provides a setpoint that will be introduced by the operator HMI normally local to the plant.

This function is completely implemented in the application software of the distributed controllers and the operator stations. It is possible for the operator to combine any turbine/generator associated to the joint control operation mode i.e. JCRP, or ICRP mode at any time. Refer to Figure 4, Typical Joint Control Reactive Power flowchart.

JCRP functionality

Reactive power and voltage control features includes:

- Dispatch center (SCADA) communication data-link
- Dispatch center generation Mvar and/or volt setpoint
- Plant Mvar and/or volt setpoint
- Reactive power capability curve monitoring
- Communication with excitation system
- Daily Mvar and/or voltage schedule
- Synchronous condenser operation
- Synchronous condenser turbine/pump modes (pumping units)

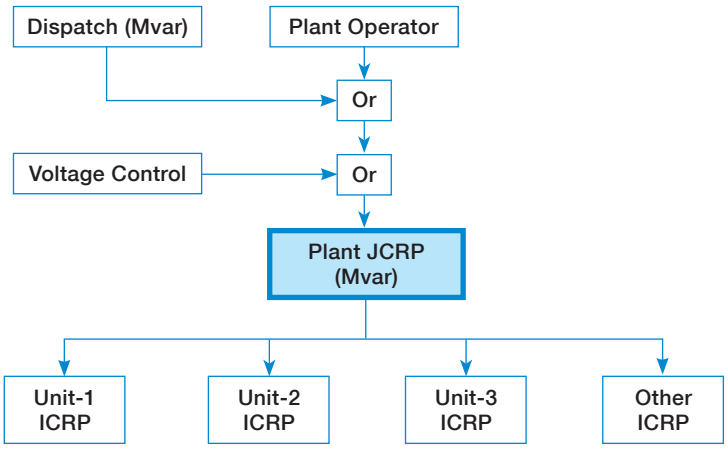

Figure 4. Typical Joint Control Reactive Power flowchart

Hydro power
Joint Control Gate Flow (JCGF)

Joint Control Gate Flow (JCGF) provides a plant the ability to receive a single flow setpoint that may be shared among a group of sluice gates. The plant flow setpoint may be either modified at the plant itself, or from any pre-designated remote location. Gates that desired to operate separately from the JCGF group may be selected to individual mode.

The **Individual Control Gate Position (ICGP)** provides a setpoint that will be introduced by the operator HMI normally local to the plant. It is possible for the operator to combine any gate associated to the joint control operation mode i.e. JCGF, or ICGP mode at any time. See Figure 5, Typical Joint Control Gate Flow flowchart.

JCGF functionality

Hydroelectric power plant, regulating dam flow control features includes:

- Remote center communication data-link
- Remote center flow setpoint
- Plant flow setpoint
- Downstream flow rate-of-change control
- Reservoir level rate-of-change monitoring
- Volume/flow control (pumped storage applications)
- Gate flow calculations
- Gate priority control
- Riparian release flow control

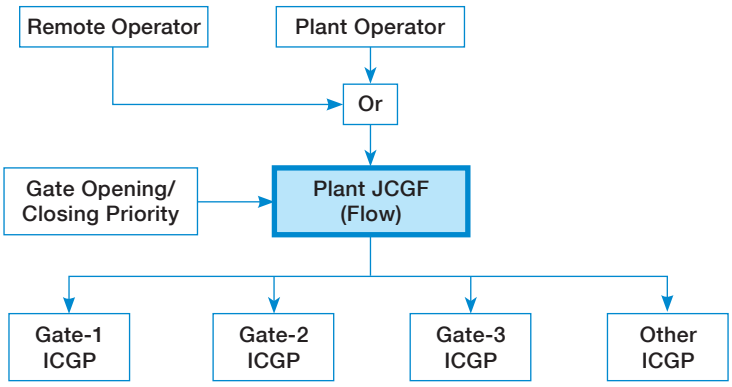

Figure 5. Typical Joint Control Flow flowchart

Hydro power
Application software

The ABB Hydroelectric Power Plant applications use the latest microprocessor based technology. These are programmed using function block type programming, selected from a set of factory built libraries for functions. In addition to function blocks, ABB controllers also supports all IEC-61131-3 programming languages: structured test, instructions list, sequential function charts, and ladder diagrams, all of which may be used to add additional custom built user functions.

Figure 6. ABB controllers: AC800M, HPC800 and SPC700

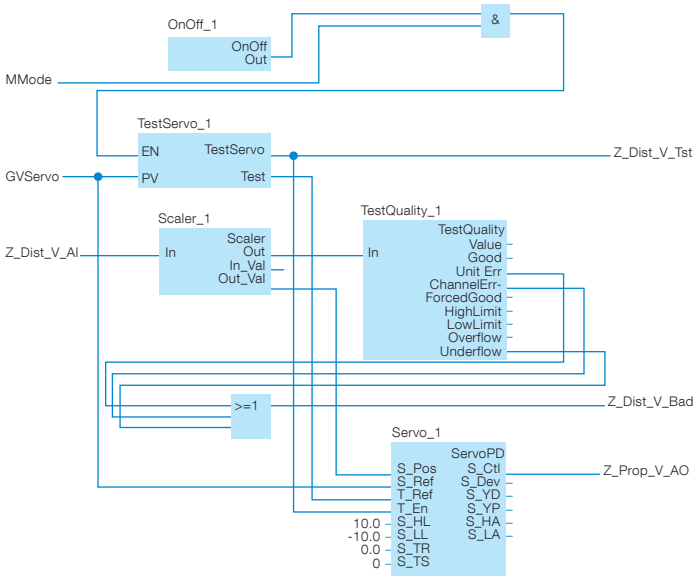

Figure 7. Typical Joint Control Flow flowchart

This diagram shows a typical logic page of a control application. It shows just a few of the many functions available in the function block libraries of the ABB controllers.

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