POWERFACTORY

PowerFactory 2021

Technical Reference

Power Frequency Controller

ElmSecctrl

PF2021

POWER SYSTEM SOLUTIONS

MADE IN GERMANY

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1 General Description

The task of the Power-Frequency Controller is to set the active power balance as typically done by the secondary control. If an unbalance between the scheduled active power values of each generation unit and the loads plus losses occurs, primary control will adapt (increase/decrease) the active power production of each unit, leading to an over- or under-frequency situation. The secondary frequency controller will then control the frequency back to its nominal value, re-establishing a cost-efficient generation delivered by each unit.

Please consider that the Power-Frequency Controller only will be active if the load-flow calculation setup dialogue, page “Active Power Control” has the option *According to Secondary Control* enabled.

Additionally, when the *Consider active power limits* option of the “Basic Options” page in the load flow command is enabled, the power limits of the machines will be considered, except for those elements (external grids, and AC voltage sources) that have no power limits specified.

2 Load Flow Analysis

The active power sources (synchronous machines, static generators, PWM-converters, external grids, and AC voltage sources with the type ”Ward Equivalent” or ”Extended Ward Equivalent”) and the bus whose frequency should be controlled must be multi-selected. A multi-selection is done by left-clicking the first element (e.g. the bus) and keeping the Control key pressed while clicking on the remaining elements (e.g. the synchronous generators).

The options to be set in the Power-Frequency Controller dialogue are the following:

Control Mode Two different modes can be selected for the active power control area exchange:

- Frequency Control
  The global frequency in the system is controlled by the units listed
- Power-Frequency Control
  The active power exchange of the grid, to which the Power-Frequency Controller belongs, is controlled. Alternatively, a user-defined boundary can be selected.

Bus bar of Frequency Measurement Bus with direct frequency measurement (Frequency Control) or bus defining the zone (Power-Frequency Control).

Area Exchange Power Set Point (Only Power-Frequency Control) Setpoint for the grid or boundary active power exchange.

Frequency Bias (Only Power-Frequency Control) Droop for correction of active power exchange in case of frequency deviations.

Active Power Distribution Contribution of the different active power sources in controlling the frequency. The percentage of each source to feed an actual value different from its set point can be set according to two different options

- According to Rated Power
  The contribution will depend on the rating of the device
- Individual active power
  The percentage of each contribution can be set individually. The sum always will be normalized to 100% during the calculation.

- According to Dispatched Active Power
  The contribution will depend on the dispatch setpoint of each machine. The wind generation scaling factors of the source's zone will be taken into consideration, as well as the out of service status.
- According to Merit Order
  The slack power is allocated to the group of generators with higher priority (lower *Merit Order* in the *Automatic Dispatch* tab of the power source dialogues) and once these generators have reached their maximum limits, then the rest of the slack is assigned to the group of generators with the next higher priority. This will continue until all the slack power has been scheduled. See Section 2.1 for more details.

2.1 Merit Order Dispatch

2.1.1 General

All the generators are grouped by their specified merit order. A merit order of 1 means that the generator is cheap, and the generator will be taken in consideration with a high priority if the system has a big load demand (positive slack). A higher value of merit order means that the generator is expensive, and therefore it will be taken in consideration with a higher priority to minimize its output in case that there is an excess of generation (negative slack).

A special case is done for generators with zero merit order, as explained below in Section 2.1.3.

2.1.2 Definition of Merit Order

The merit order of each machine is specified in the "Automatic Dispatch" tab of the "Load Flow page" of the element dialogue. The *Merit Order* parameter is only visible when the option *Generator Dispatch* is set to *Dispatchable*.

2.1.3 Merit Order Assignment Process

The process of slack assignment follows these steps during the outer loops in the load flow command:

Initial distribution Initially, all generators that are out of limits are brought into their limits specified, and the slack power created by this will also be considered.

The first step is to assign a participation factor to each participating generator in order to solve the first iteration of the power flow calculation. Each generator is given a normalized participation factor (Kp) according to its capability range $Pmax - Pmin$. This allows the controller to calculate the initial slack power and achieve convergence.

Distribution of slack power through priority From the second outer loop on, the slack can be distributed according to the priority of the generators.

When the slack power is positive, this is allocated first to the group of generators with the lowest *merit order* (in the *Automatic Dispatch* tab of the power source dialogues) and once these generators have reached their maximum limits, then the rest of the slack is assigned to the group of generators with the next higher *merit order*. This will continue until all the slack power has been scheduled.

The participation factor of each generator is based on its reserve capacity ($maximum\ limit - setpoint$).

On the contrary, when the slack is negative, the negative power is allocated to the group of generators with the highest *merit order*, and once these generators have reached their minimum limits, then the rest of negative slack is assigned to the group of generators with the next lower *merit order*. This will continue until all negative slack power has been scheduled.

In this case, the participation factor of each generator is based on its curtailment capacity ($setpoint - minimum\ limit$).

For both cases, this step is done in two parts. After the higher priority groups of generators have reached their maximum or minimum limits, the remaining slack power is distributed first among all the rest of generators with lower priority, using either the reserve or curtailment capacity, in order to make sure that there is convergence in case the slack changes due to the behaviour of other elements in the system (e.g. transformer tap adaptations). Once the slack is not variable any more, then the slack is totally absorbed by the next priority group of generators.

Distribution of slack power through zero-priority group All the generators with zero *merit order* and a valid value of *Primary Frequency Bias* (Kpf) are grouped in the zero-priority group. If there is remaining slack power after the previous step, then the slack is distributed using the *primary frequency bias* as a participation factor.

Distribution of slack power to the reference machine Finally, any remnant slack power that can not be assigned in the previous steps, the reference machine will absorb it, by not respecting its minimum or maximum limits.

3 Usage Hints

Similar to the station control, the *Power-Frequency-Controller* is a *PowerFactory* element that cannot be visualized directly in the single line diagram. However it is a specific calculation element, which is also listed when selecting the icon *Objects relevant for the calculation*. Its icon is shown as . If you experience problems with the Power-Frequency control, you may check whether multiple Power-Frequency controllers are defined for the same bus or zone, as these may result in conflicts during the calculation.