HC900 Hybrid Controller

When you need more than just discrete control

Ramp Function Block – Product Note

Background:
Many processes use multiple valves, pumps, compressors, generating units or other sources of energy to satisfy the changing needs of a broad range of process demands. Examples would be multiple boilers that are brought on-line as needed to satisfy steam demand, or multiple pumps used in tank level control where pumps are brought on-line as level rises or falls to maintain level within a desirable range. In these applications the number of units brought on-line at any given time is determined by the amount of error between the desired setpoint and the actual process measurement. The greater the error, the more units brought on-line. The control strategies used in these applications often employ regulatory control of each supply unit such as variable speed pumps or proportional control of boiler outputs. As the capacity of one supply unit is exceeded, a second unit is brought on-line to satisfy demand.

Problem Statement:
A problem that frequently occurs in this control strategy is that each supply unit has a practical low limit to its operating parameters, and as it is brought on-line it provides a step change to the total control output. The ideal control implementation would be to allow the new unit to come up to its optimal operating range while ramping down the unit that was running at maximum capacity. With this operation, the starting point for the two supply units equals the maximum output that was present on the single unit at the time the second unit was activated. From this point both units would be regulated equally. If demand continues to increase, both units would increase their outputs until both reach maximum capacity, at which time a third unit would be brought on-line. The new unit coming up to its operating range and the ramp down of the two existing units would again occur so that the sum of the 3 outputs equals the total of the two previous outputs. This ramping

down of operating units while bringing up new units serves to minimize the step change impact of units coming on-line.

The above control conditions occur when demand is increasing and units are being added to the total available supply component. The same sequence can occur when demand is decreasing and units are being taken off-line. In this sequence, as units are disabled and their outputs decreased, the units that are to remain running are ramped up to compensate for the reduction in total capacity. The goal is to minimize the peaks and valleys that may naturally occur when supply units are added or deleted from the total available supply component.

Control Solution:
The HC900 Ramp algorithm provides an easy to setup and operate solution to this control problem. A single HC900 Ramp algorithm can control up to 4 ramp output transitions, which relates to turning ON or OFF four boilers, pumps or other supply components. If the application exceeds four units, the HC900 Ramp algorithms can be connected in cascade mode so that the appropriate ramping sequence can extend to multiple HC900 Ramp function blocks. The HC900 controller can support up to a maximum of 8 Ramp algorithms.

Operation of the HC900 Ramp function block is as follows. See Figure 1 for a graphic representation of the Ramp function block. The Ramp function block has one analog input and one analog output. The primary function of the block is to apply gain and bias to the input value and send the adjusted value to the block output. The Ramp function block is partitioned into 4 gain and bias sections, each with its own digital enable input pin. The gain and bias partitions are prioritized from bottom to top so that if all gain and bias partitions are enabled, only the bottom partition is operational. To simplify gain and bias settings, user entered engineering units are used to define the re-scale input and output values allowing the appropriate gain and bias values to be automatically determined. Separate Ramp-up and Ramp-down slew rate adjustments are provided for the block to control the rate of change of the output when switching from one partition to another. An example of the Ramp function block in operation follows:

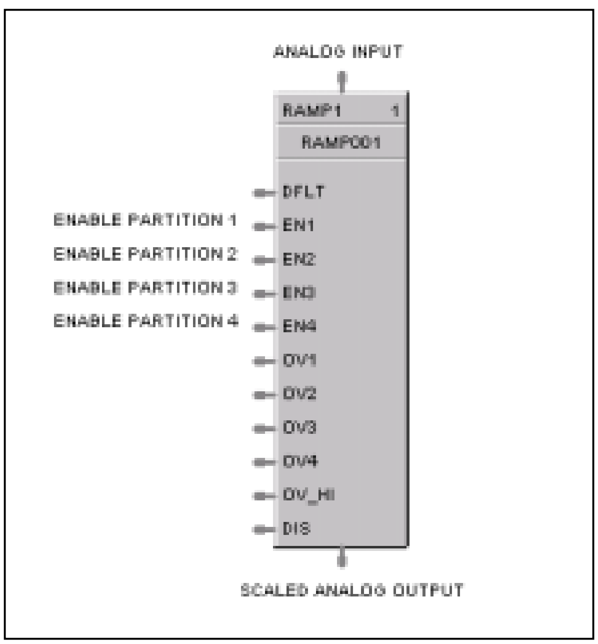

Figure 1

In our example a demand signal with a range of 0 to 100% is connected to the analog input of the ramp block. The Ramp block output is connected to the firing rate controls of four boilers so that all four boilers see the same Ramp output signal. Each of the four boilers is assumed to have the same capacity and will be controlled using a firing rate signal of 0 to 100%. Separate control logic, such as a HC900 Stage algorithm, determines when to activate or deactivate a boiler. The same signal that activates additional boilers selects the next Ramp partition in sequence. In this example an additional boiler will be activated for each 25% of range of the demand input signal. The output of each operating boiler will reach 100% before the next boiler in sequence is added. i.e. Boiler 1 for 0% to 25% demand, boilers 1 and 2 for between 25% and 50%, boilers 1, 2, and 3 for between 50% and 75%, and all four boilers between 75% and 100%.

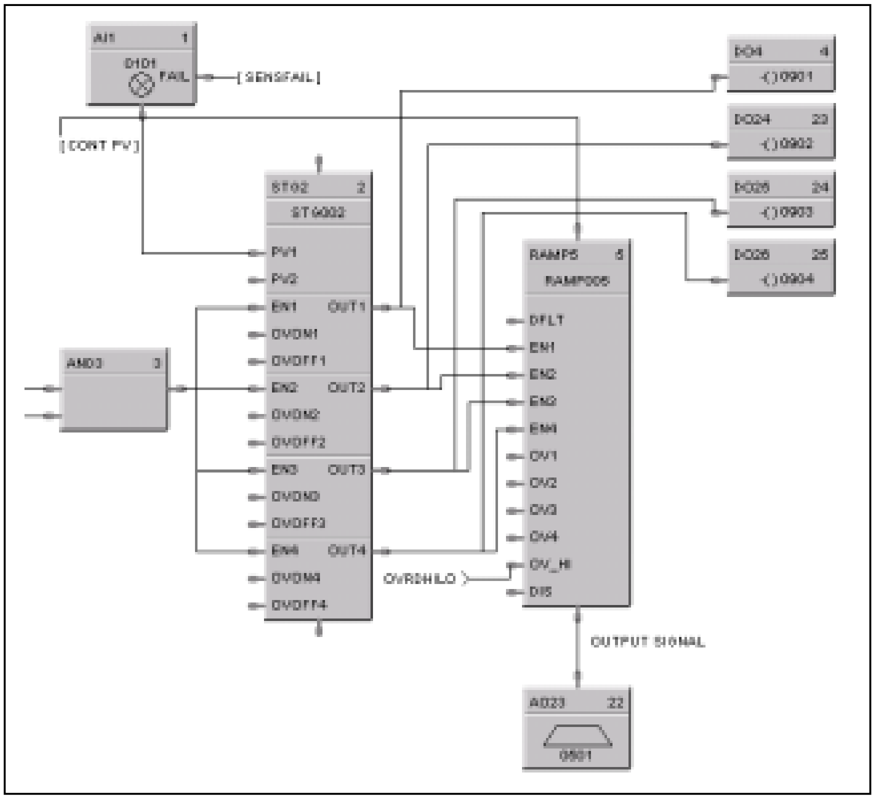

Figure 2

The recommended scaling of the four partitions of the ramp algorithm to minimize steps in the total output as additional units are brought on-line is as follows:

	Input Low Scale	Input High Scale	Output Low Scale	Output High Scale
Partition 1	0	25	0	100
Partition 2	25	50	50	100
Partition 3	50	75	66.6	100
Partition 4	75	100	75	100

The resulting demand vs. total control output would appear as indicated in figure 3.

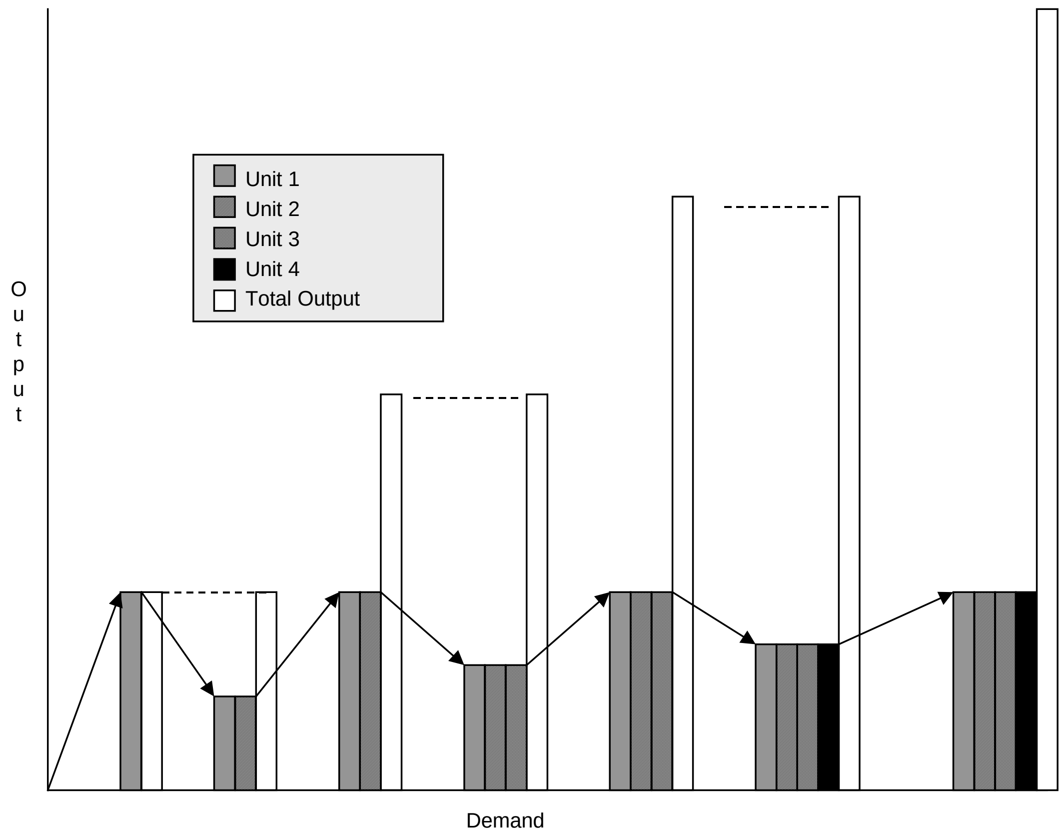

Figure 3

In this example, when the Stage algorithm calls for an additional boiler to be activated it also selects the next ramp partition, which calculates a new output value based on the existing input value. Using the scaling factors in table1, the new output value would maintain the same total output by compensating for the additional boiler's capacity. A user entered decreasing rate of change limit value controls the rate at which the output can be reduced . Under normal operation when a new unit is started, the output of the running units begin to ramp down to compensate for the additional supply resource since all running units will be set to operate at the same rate.

When demand is decreasing, the same operation occurs in the opposite direction and a user entered increasing rate of change limit controls the rate at which the output can increase.

The HC900 Ramp algorithm provides a number of additional features that may be used to satisfy process variations including; block disable, analog input filter, override calc. set output high, override calc. set output low, and use default value. Connecting the output of a Ramp block to the Default Input of a second Ramp block allows cascading Ramp algorithms when more than four units are being managed.

The Ramp algorithms of the HC900 Controller are supported with dedicated operating displays when used with a 1042 Operator Interface. These displays allow on-line editing of the Input Filter Time Constant, Increasing and decreasing transfer rates, and input or output high and low scaling limits for each partition.

Summary

The HC900 Ramp algorithm provides a powerful control function when applied to the appropriate process. Use of the Ramp algorithm saves valuable configuration time and conserves significant programming resources when compared to other logic controllers performing the same function.

Other application hints:

The Ramp function block may be used to rescale any analog variable to new engineering units by simply assigning input high/low limits and output high/low limits and enabling the selected partition.

Since the output value of the Ramp block will not exceed the output scaling limits for the selected partition, regardless of the value of the input, the Ramp algorithm may also be used as a signal limiter.