SIEMENS

APPLICATION DATA

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Procidia Control Solutions
Coarse/Fine Control

This application data sheet describes implementing a coarse/fine control strategy in a Siemens Procidia™ 353 controller.[1]

A coarse/fine control strategy uses two final control elements (FCE's), one large and one small, connected for an additive affect on the process. The large FCE supports large changes in the manipulated variable, but often lacks resolution. To improve resolution and increase turndown, the small FCE, which has better resolution, is used to trim the large FCE.

Coarse/Fine control is sometimes called "big valve/little valve" control. Figure 1 shows a system that employs this strategy for pH control.

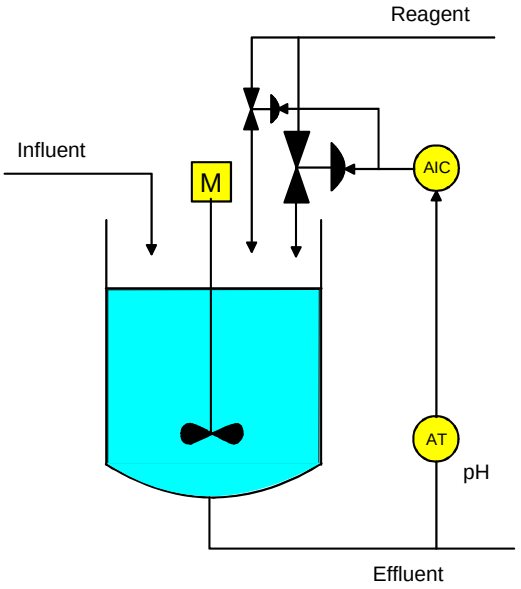

Figure 1 Coarse/Fine pH Control

There are several coarse/fine control strategies: split-range control, floating control, and center-seeking control. Each will enable precise flow control which will improve product consistency.

A coarse/fine control strategy can be easily implemented in a 353 controller. The following sections discuss each method, the theory of operation, advantages and disadvantages, and how it can be configured in a 353.

Split-Range Control

The split-range control strategy, shown in Figure 2, involves closing the coarse valve and manipulating only the fine valve when the flow demand is low. As flow demand increases, the fine valve is gradually opened until fully open. It then remains open as the coarse valve is manipulated.

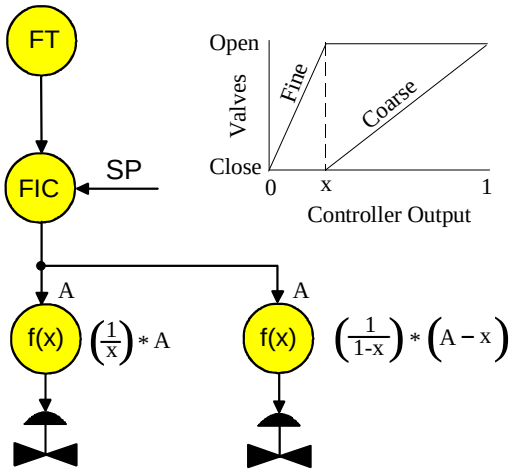

Figure 2 Split Range Control

This scheme features immediate response to demand changes and fine resolution for low flow demands. However, resolution becomes coarse when the demand exceeds the capacity of the fine valve, but this is a simple method to provide high turndown flow control.

[1] See Application Support at the back of this publication for a list of controllers.

A split-range control configuration is shown in Figure 3. The PID function block determines the flow demand after comparing a controlled variable signal from analog input 1 (AIN1) to the setpoint signal from SETPT. The A/M transfer function block supports manual control of the valve positions.

The rate at which the coarse valve moves is relatively slow and is proportional to the difference between the fine valve signal and its exceeded limit. As the coarse valve moves, the fine flow controller responds by returning the fine valve to within its limits, at which time the coarse valve holds at its new position. The coarse flow controller must be tuned for slow response to ensure that the flow loop remains stable.

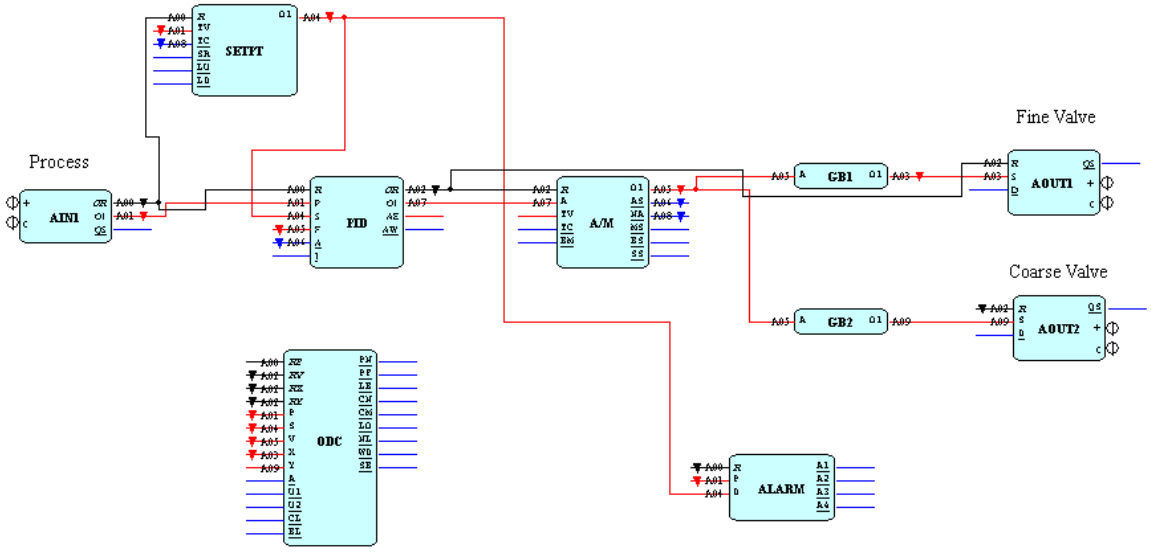

Figure 3 Split Range Configuration (CF353-118SR)

The Gain & Bias function blocks GB1 and GB2 provide the scaling to analog output blocks AOUT1 and AOUT2. For this example, the value of x (see the formulas in Figure 2) was selected as 20% (0.2). Therefore, the output of GB1 is O1 = 5.0(1.0A + 0.0) + 0.0 and the output of GB2 is O1 = 1.25(1.0A – 20.0) + 0.0[2]. This ensures the coarse valve does not begin to open until the fine valve is fully open. Also, the demand signal is multiplied by a factor which allows the coarse valve to open fully at the highest flow demand.

Floating Control

The floating control strategy, shown in Figure 4, adjusts only the fine valve as long as the valve remains within configured limits (between 25% and 75% of scale, for instance). It adjusts the coarse valve only when required to keep the fine valve within the configured limits. In this strategy, a controller function block manipulates the fine valve. When the controller output exceeds the limits of the fine valve, a separate integral controller moves the coarse valve.

This strategy responds quickly to small flow demand changes over the entire demand range by directly adjusting the fine valve. However, it responds slowly to a large demand change that saturates the fine valve, but this is an easy technique to get accurate flow control over a large range.

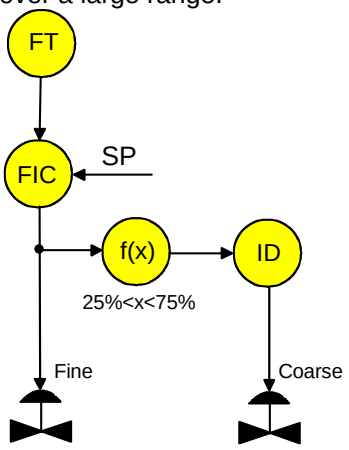

Figure 4 Floating Control

Figures 5 and 6 show a floating control configuration. In this configuration the fine PID function block located in loop 1 determines the fine valve signal. The A/M transfer function block allows manual control of the valve positions. The ID function block located

[2] See the Gain & Bias function block in the Functions Blocks section of the controller User's Manual for details concerning the block and formula.

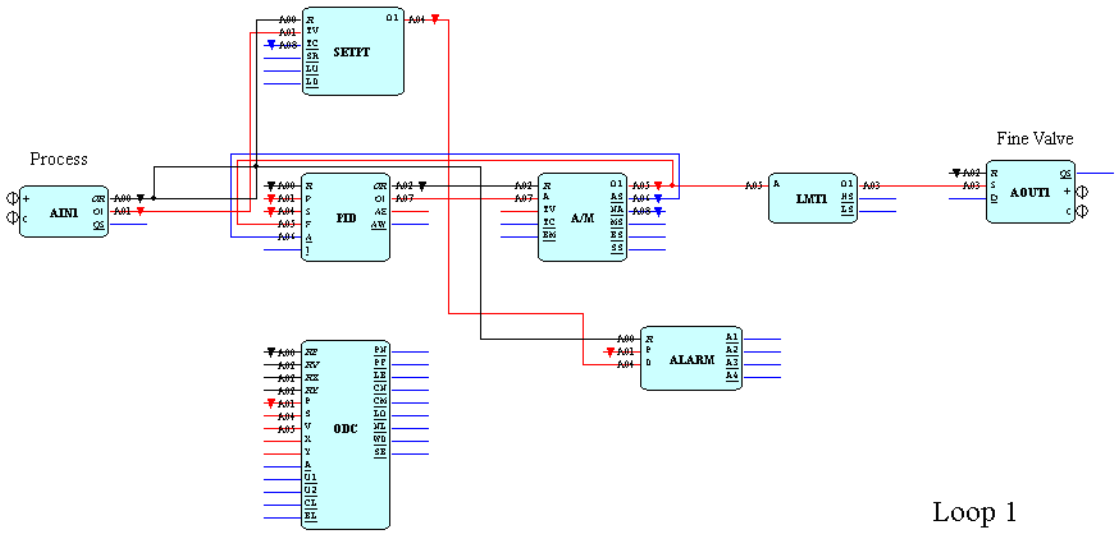

Figure 5 Fine Valve Floating Control Configuration (CF353-118FC)

in loop 2 is used as a floating or integral only controller.

The Limit function block LMT1 in loop 2 limits the fine valve signal to between 25% and 75%. This allows a difference to develop between the P and S inputs to the ID controller when the fine valve signal moves outside these limits. This error causes the coarse flow controller to move the coarse valve.

The fine PID controller in loop 1 responds to changes produced by the coarse valve by returning the fine valve to a position within the limits. This causes the error at the coarse flow controller to become zero, which holds the coarse valve at its new position.

Center-Seeking Control

The center-seeking control strategy, shown in Figure 7, is similar to the floating strategy. It involves manipulating only the fine valve when the valve signal is between certain trip points, but when a trip point is reached, the coarse valve is adjusted until the fine valve is returned to 50%, midstroke. This differs from the floating control, which returns the fine valve to the trip point rather than 50%.

Like floating control, this strategy responds quickly to small changes in flow demand over the entire range by directly adjusting the fine valve. However, it responds slowly to a large demand that saturates the fine valve. The advantage of center-seeking control is that it returns the fine valve to where it can respond alone to larger changes in either direction.

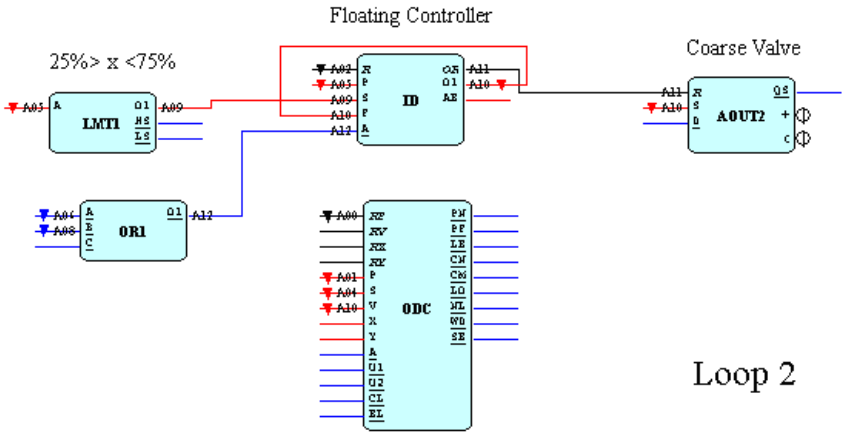

Figure 6 Coarse Valve Floating Control Configuration (CF353-118FC)

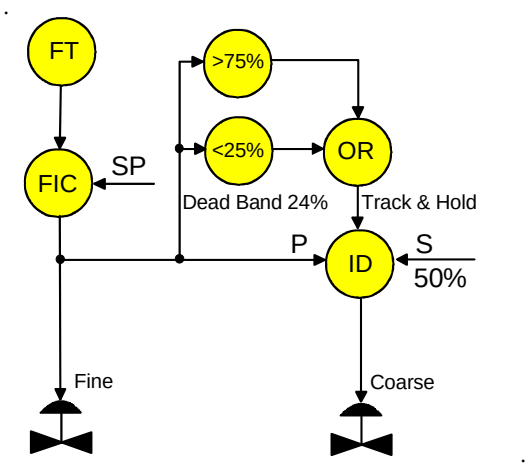

Figure 7 Center Seeking Flow Control

Figures 8 and 9 show a center-seeking control configuration. In this configuration the fine PID function block located in loop 1 determines the fine valve signal. The A/M transfer switch allows manual manipulation of the fine valve signal. The ID function block located in loop 2 is used as a floating or integral only controller and adjusts the coarse valve position when a fine valve trip point has been reached. The setpoint for the coarse valve controller is a constant value of 50%.

The Comparator function blocks CMP1 and CMP2 determine when the fine valve signal has reached either the high or low trip point. The deadband adjustment in each Comparator function block enables the fine valve controller to return the valve to approximately 50% before the floating controller is stopped and held at its last position.

The OR1 function block provides a track and hold signal to the coarse flow controller. When a trip point is reached, a high (1) signal from a comparator returns the ID controller to its automatic mode enabling it to move the coarse valve. This action causes the fine valve controller to move its valve toward the 50% position.

The coarse flow controller tracks (holds its output) if a fine valve trip point has not been crossed or the A/M function block in loop 1 is in the manual mode. The Quick Hold function block QHD1 in loop 2 allows manual adjustment of the coarse valve independent of the fine valve position. The Quick Set hold value can be adjusted, provided the block is not in a tracking mode which occurs when the ID controller is in automatic. The Quick Set hold value can be adjusted from the local faceplate using the QUICK button or from the loop detail screen in i|ware™.

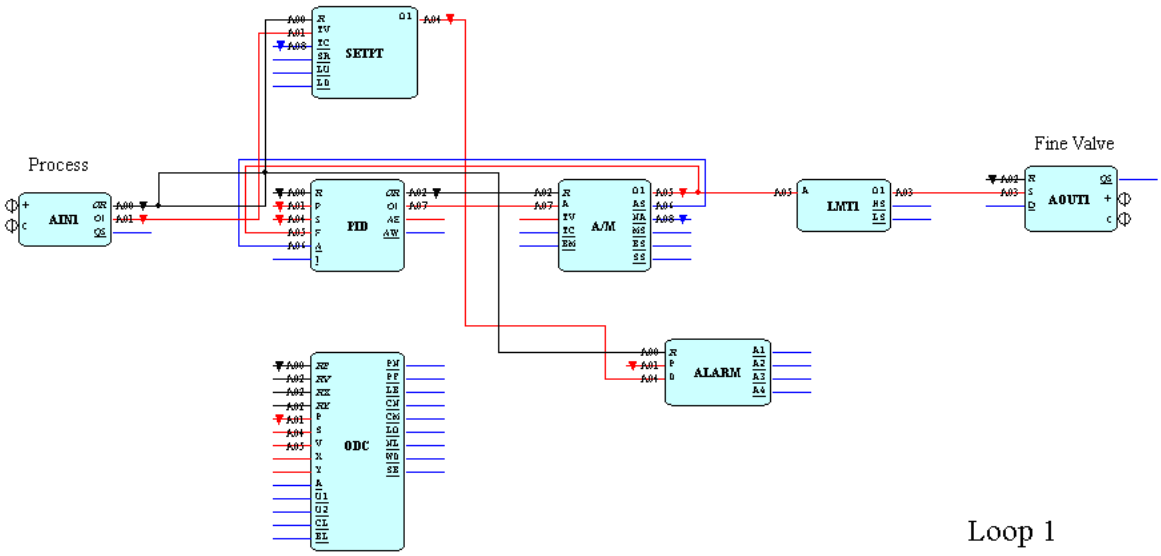

Figure 8 Fine Valve Center Seeking Control Configuration (CF353-118CS)

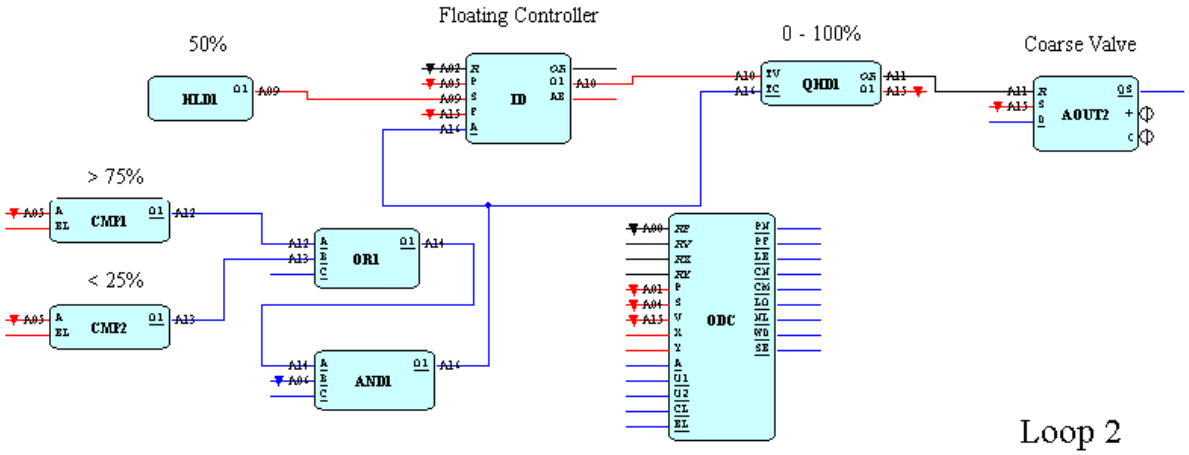

Figure 9 Coarse Valve Center Seeking Control Configuration (CF353-118CS)

Applications

In addition to the pH control system shown in Figure 1, a coarse/fine control strategy can be implemented on many process requiring precise flow control. One of the above strategies can be implemented based on the characteristics of the flow such as frequency of changes in flow demand and the range of these changes.

Application Support

User manuals for controllers and transmitters, addresses of Siemens sales representatives, and more application data sheets can be found at www.usa.siemens.com/ia. To reach the process controller page, click **Process Instrumentation** and then **Process Controllers and Recorders**. To select the type of assistance desired, click **Support** (in the right-hand column). See AD353-138 for a list of Application Data sheets.

The configurations shown in this publication were created in Siemens i|config™ Graphical Configuration Utility. Those with CF353 in parenthesis in the figure title are available using the above navigation, then click **Software Downloads** > **Coarse Fine Control (Reference AD353-118)**.

The configuration(s) can be created and run in a:

- Model 353 Process Automation Controller
- Model 353R Rack Mount Process Automation Controller*
- i|pac™ Internet Control System*
- Model 352*Plus*™ Single-Loop Digital Controller*

* Discontinued model