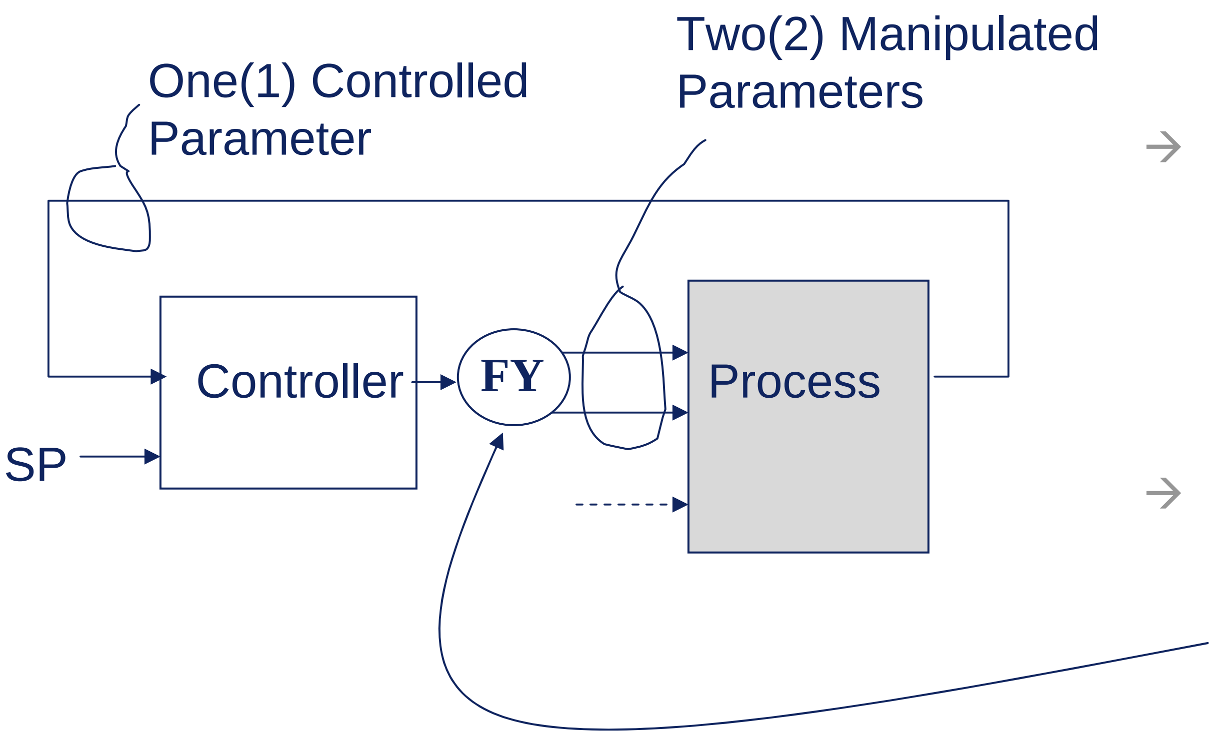
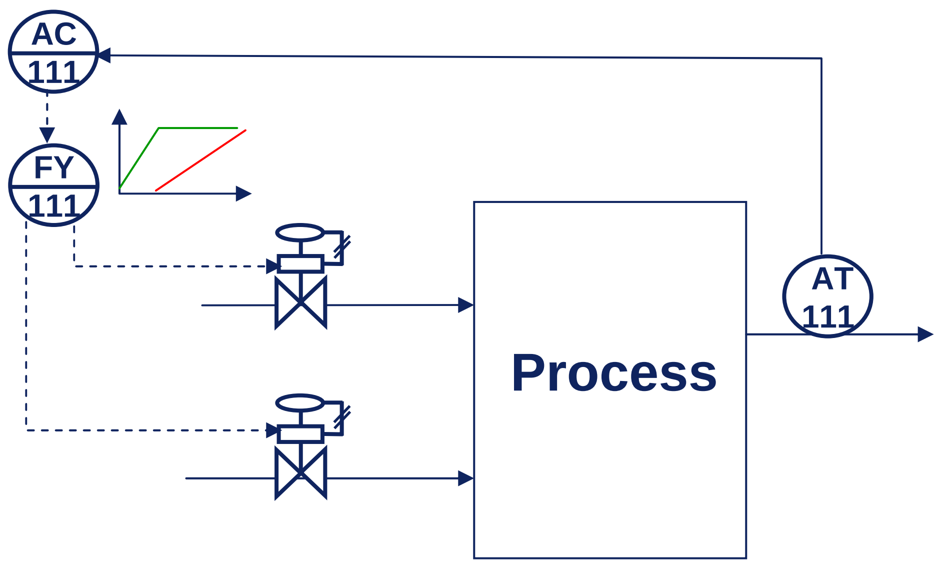
Control Using Two Manipulated Inputs

Control Using Two Manipulated Parameters



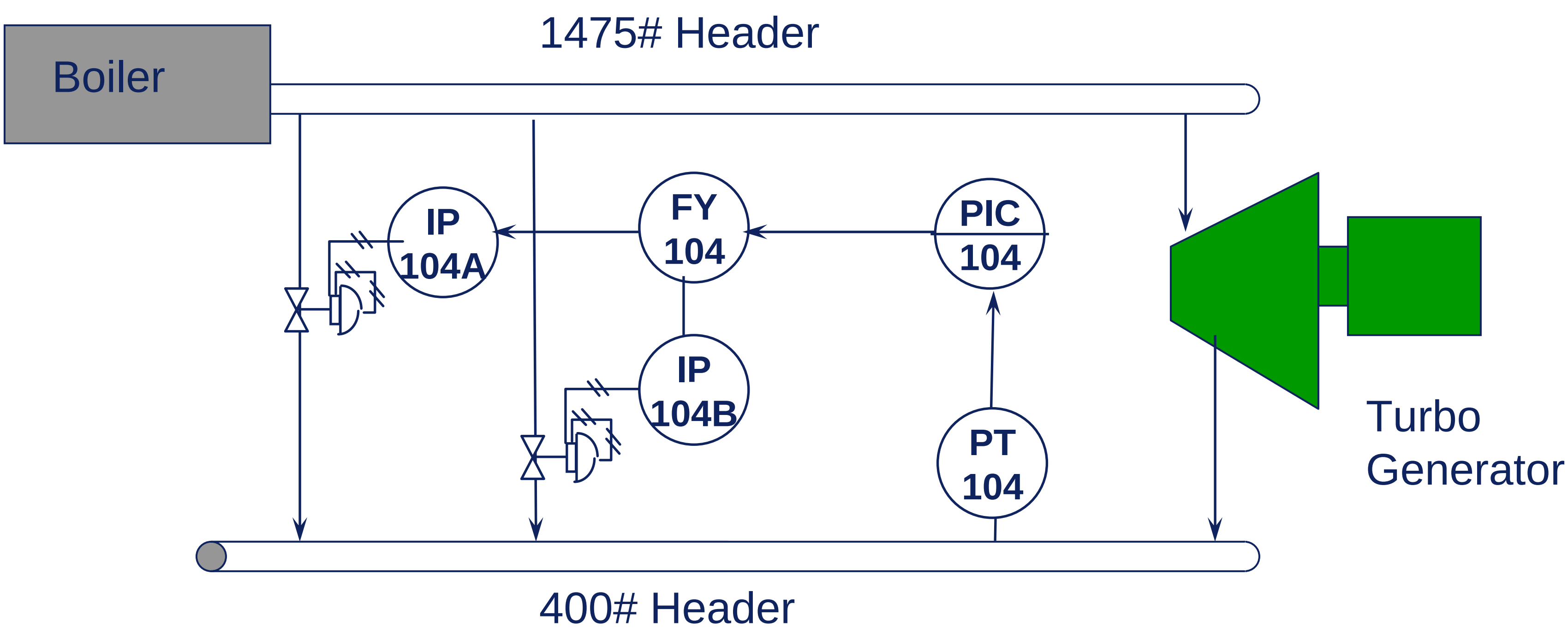
- Under specified problem that has multiple solutions for unlimited operation.
- Extra degree of freedom is used to achieve unique solution that satisfied specific control objective.
- Most common techniques are: ***split range, valve position, and ratio control***

Basis – Split Range

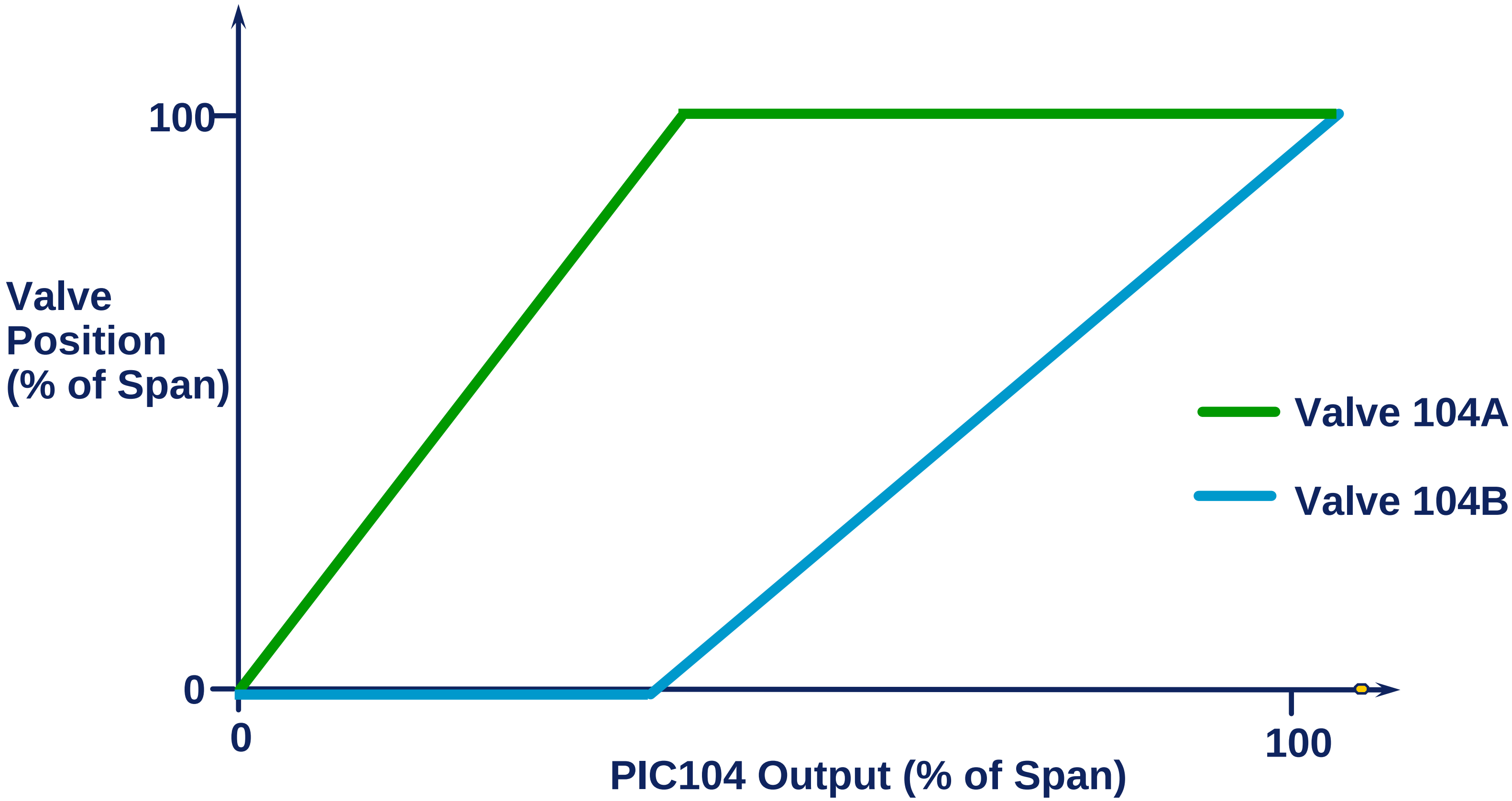


- In some cases, two or more inputs to the process are used as one input.
- The inputs to the process are maintained in a fixed relationship as determined by a splitter station characterization and station setpoint.

Steam Header Example



Split Range Output (FY104) - Capacity



Calculating Splitter SP Ranges

Example: Steam flow to Header, splitter interfacing directly to PRV's, no overlap

Valve 1 rating = 50kph

Valve2 rating = 150kph

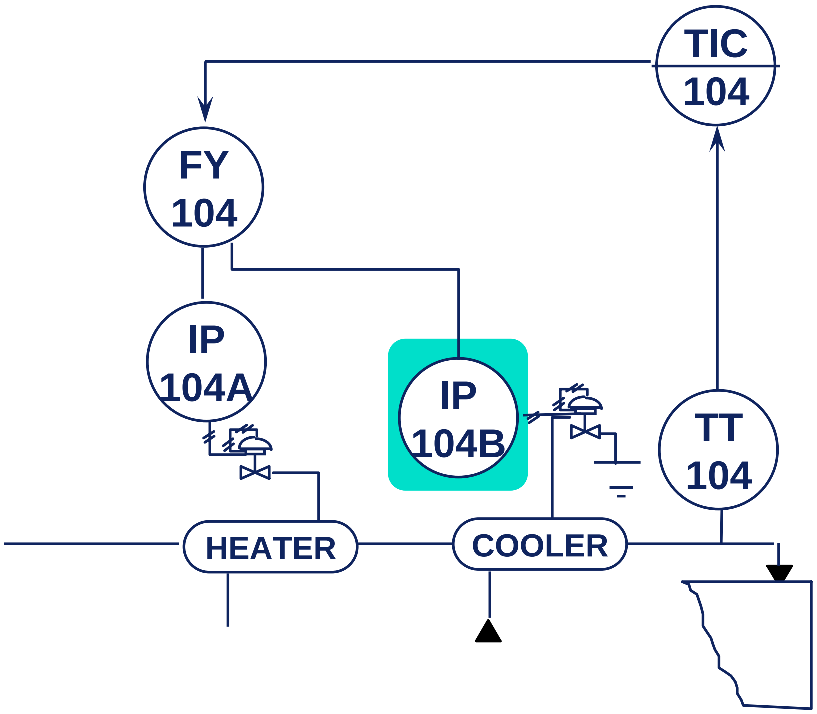
Desired Splitter Span valve 1 = 100*(50/(150+50)) = 25%

SP range for valve 1 = 0-25%

SP range for valve 2 = 25-100%

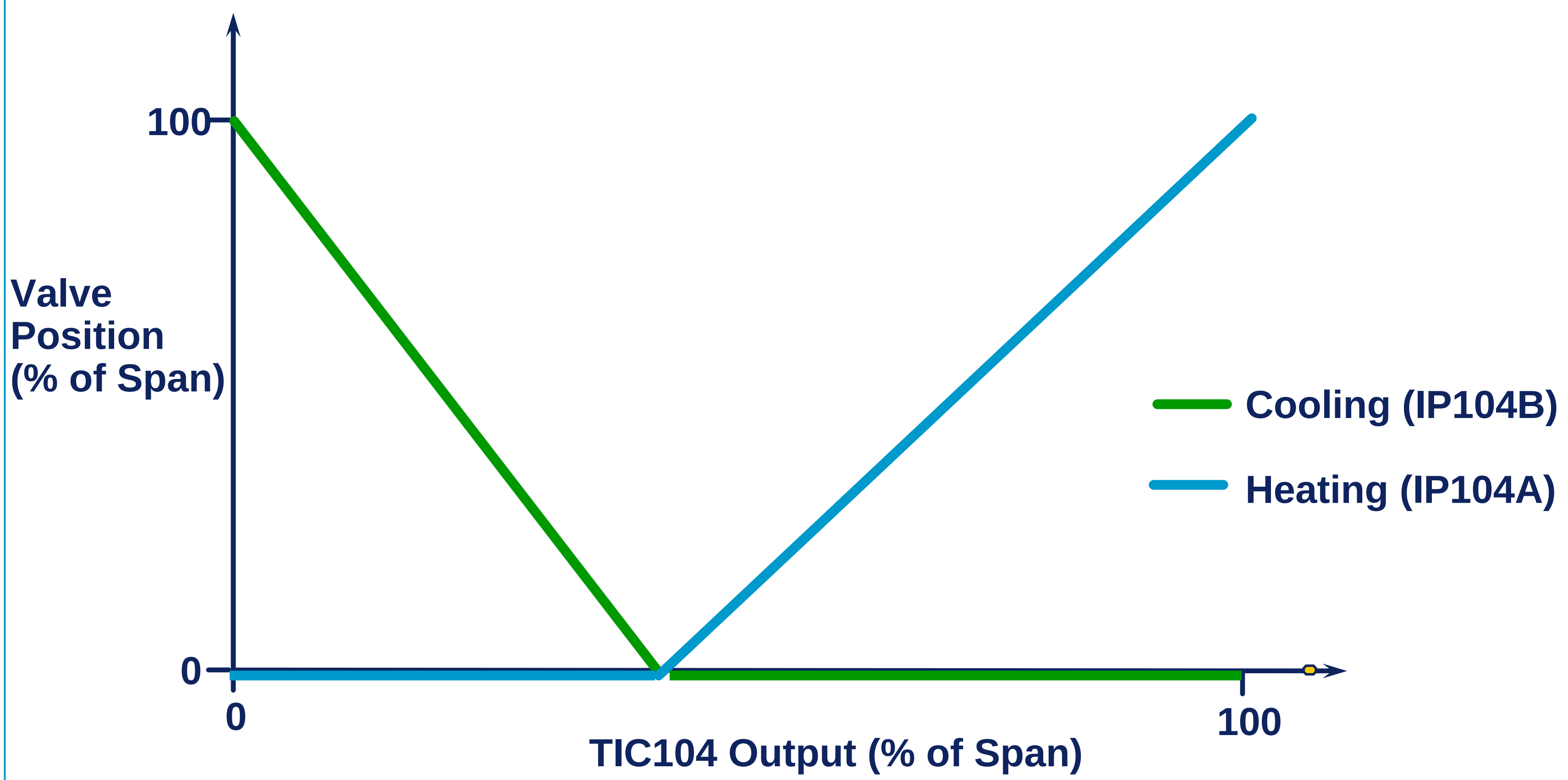
- A 1% change in controller output to the splitter should have the same impact on control parameter when operating with either valve.
- When manipulating the same or similar material e.g. steam flow to header, then the range may be calculated based on valve rating.
- Tests may be performed to determine impact of each valve on the controlled parameter.

Example - Split Range Control



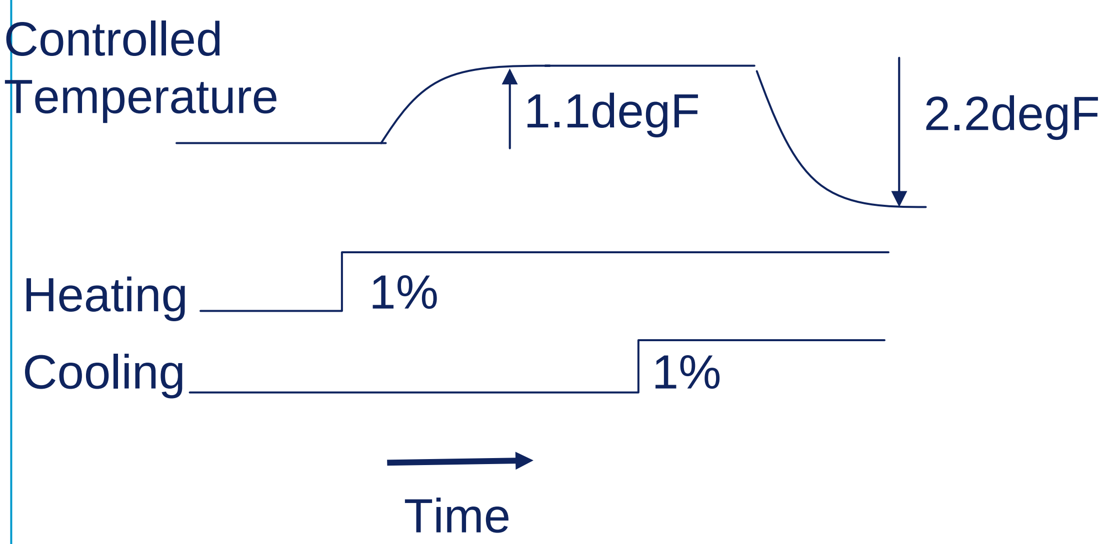
- Temperature control using cooling and heating
- Valves are sequenced in a fixed relationship to the temperature controller output

Split Range Output (FY104)



Testing Process to Determine Splitter SP Ranges

Example: Temperature controlled using heating and cooling valves

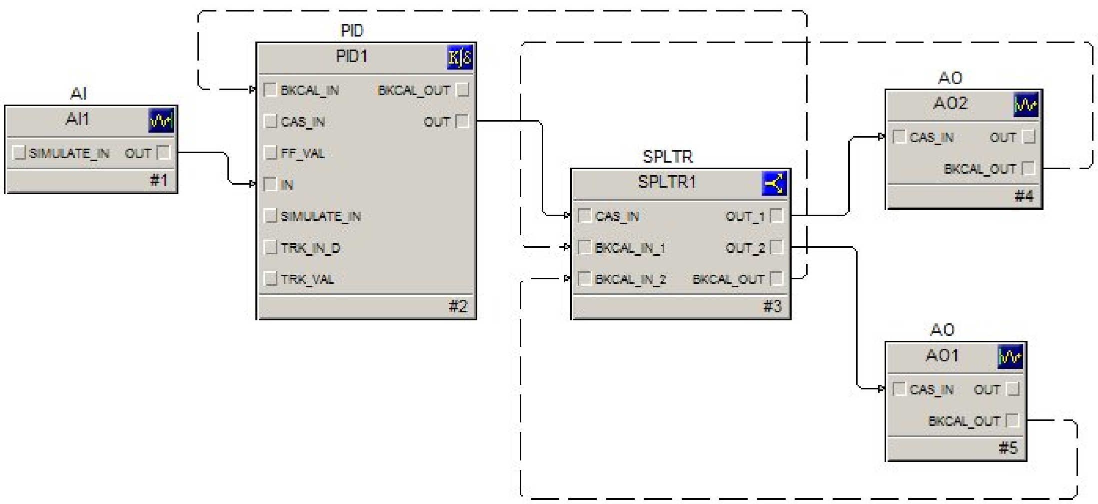


Desired Splitter Span cooling valve = 100*(2.2/(1.1+2.2)) = 66%

SP range for cooling valve = 0-66%
SP range for heating valve = 66-100%

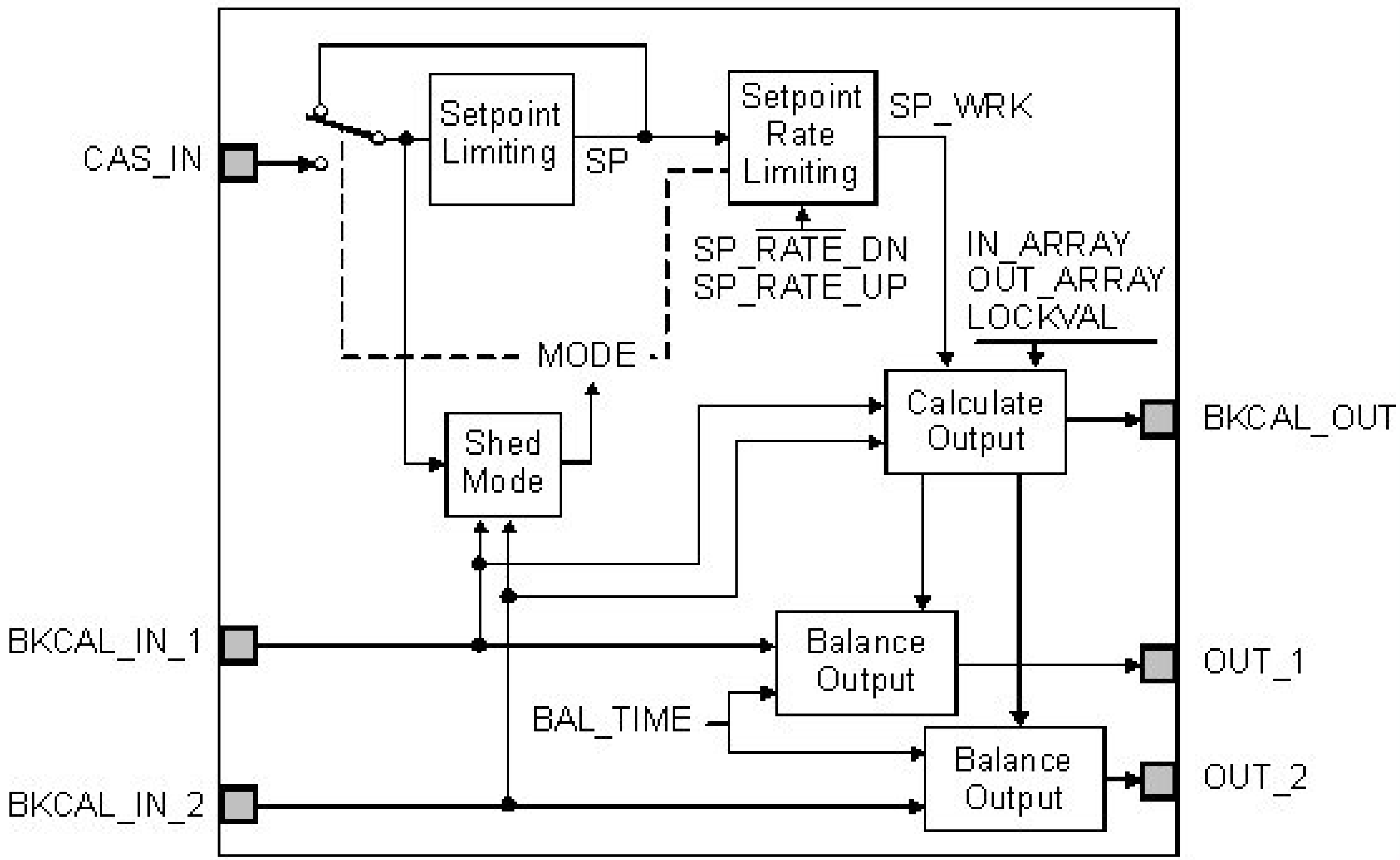
- With the process at steady state and AO's in Auto mode, determine the magnitude of change in the controlled parameter for a 1 percent change in each valve.
- Calculate the splitter SP span and range for each output based on the observed response

Split Range Control in DeltaV

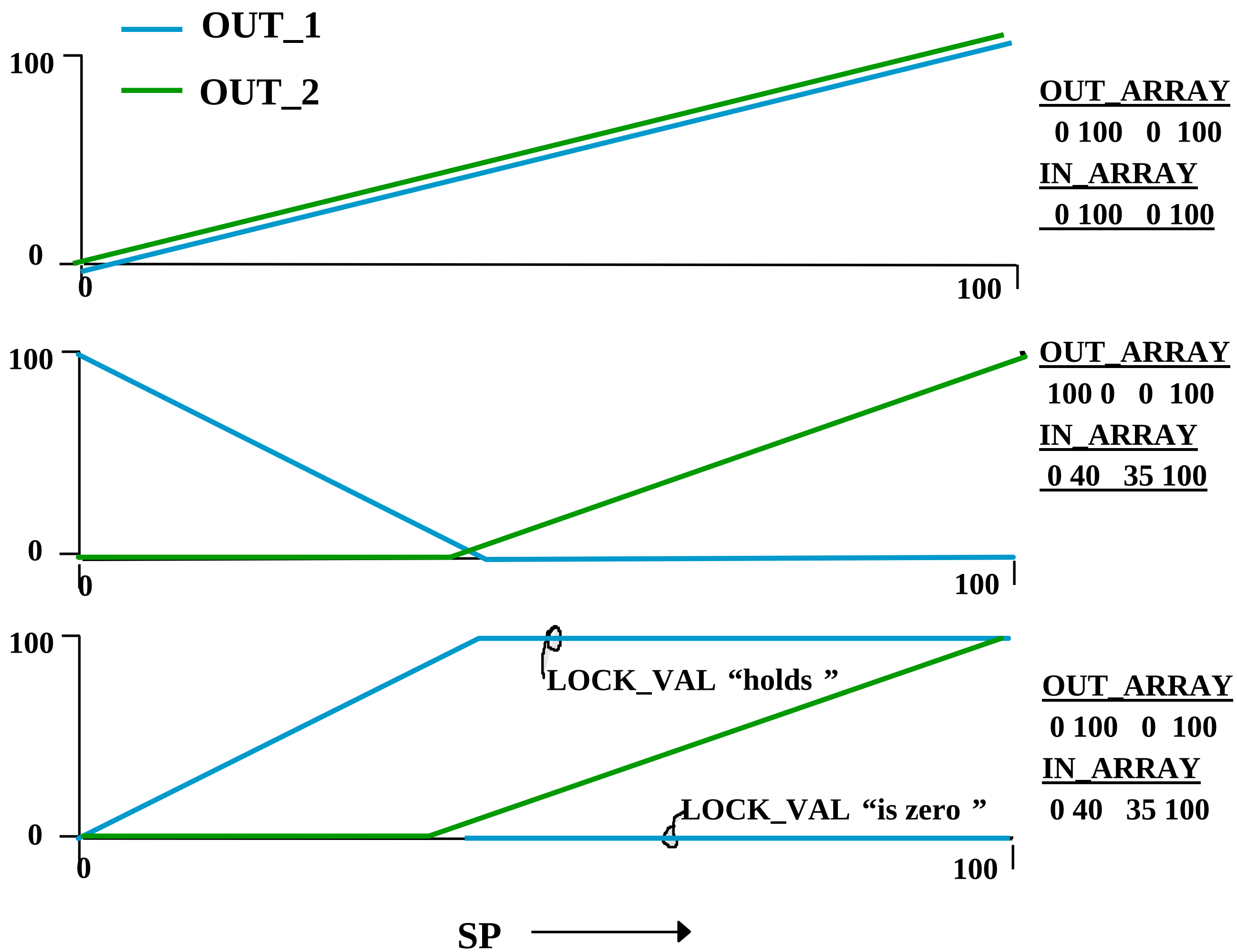


- Splitter bock is used to implement split range control.
- Split range control is most often implemented using AO blocks for direct interface to valves.

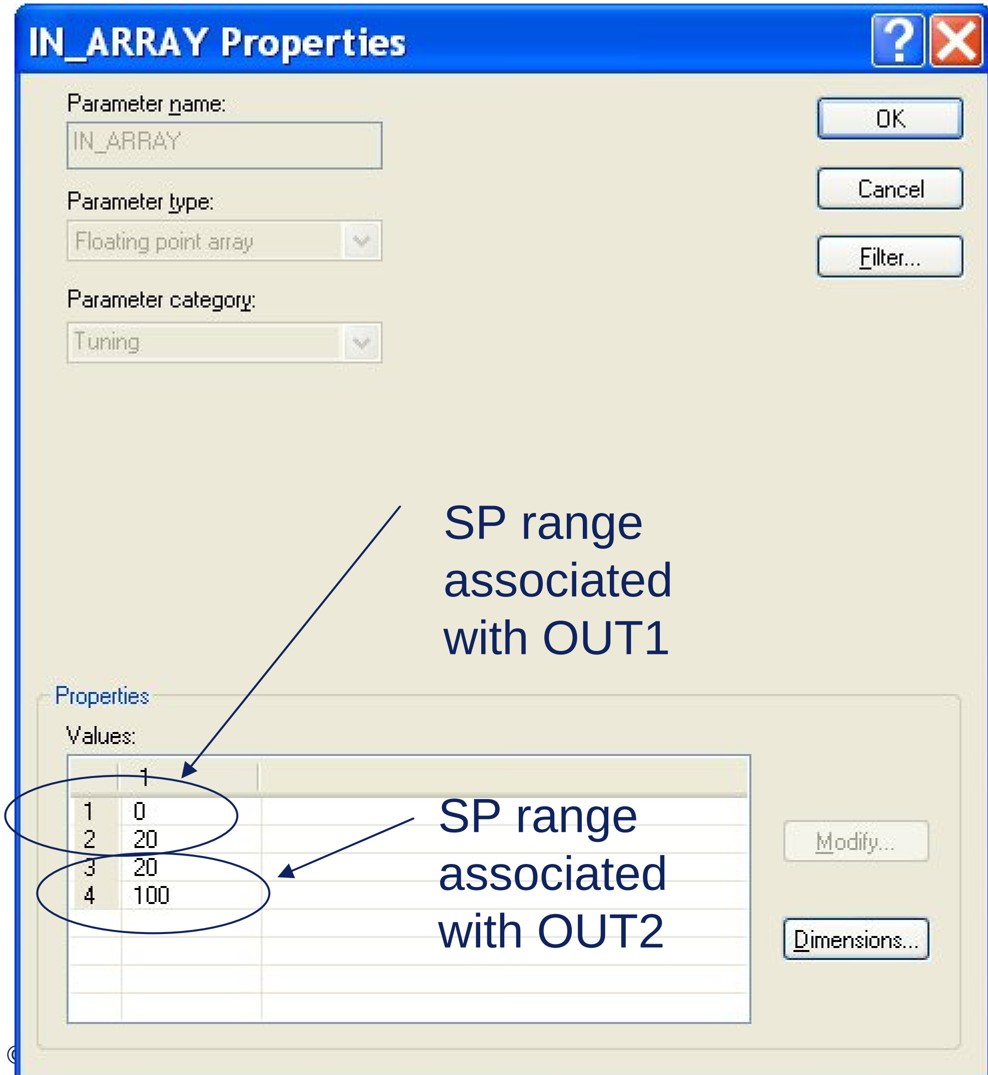
Splitter Block Calculation



Splitter Block

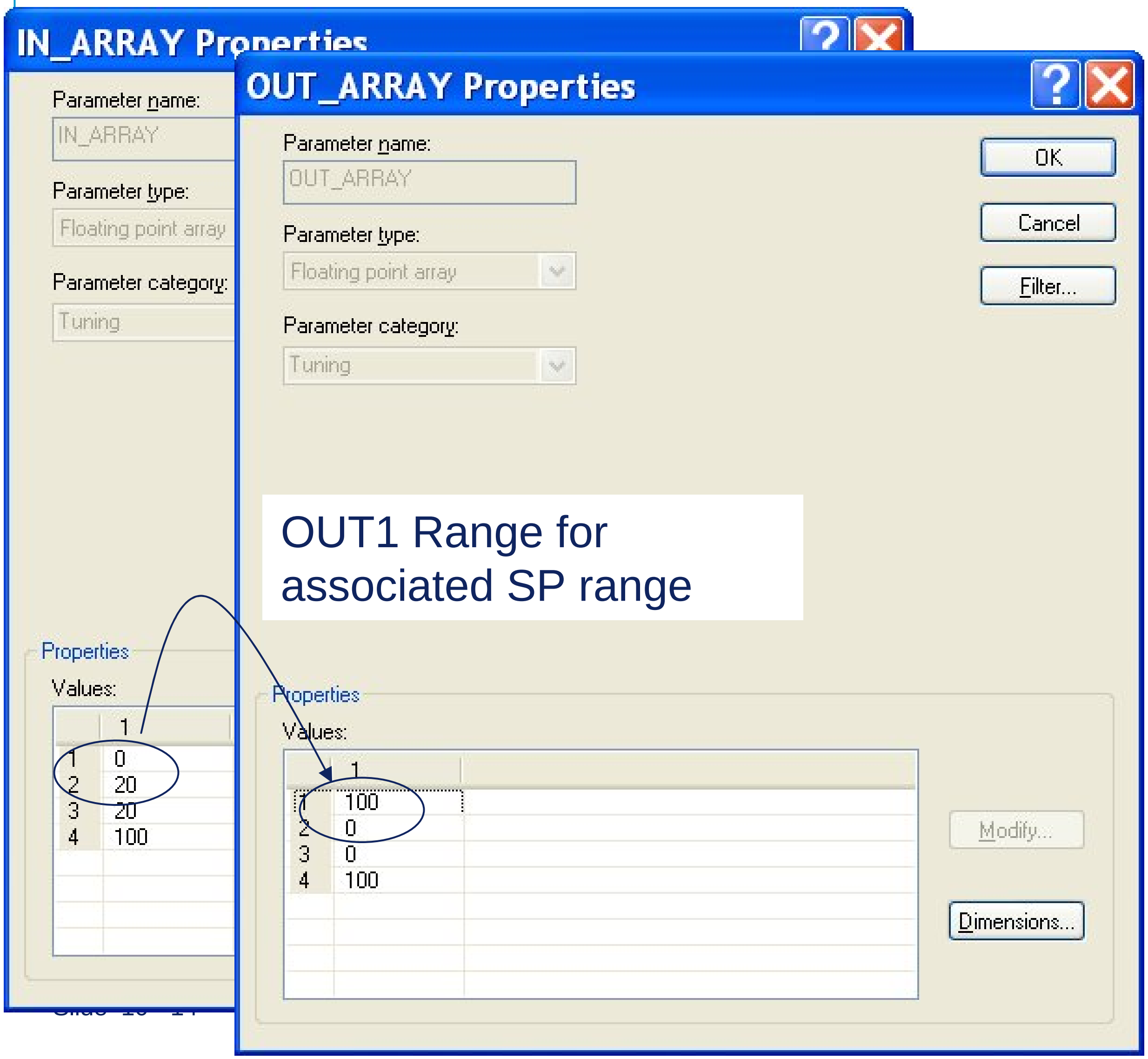


IN_ARRAY Parameter



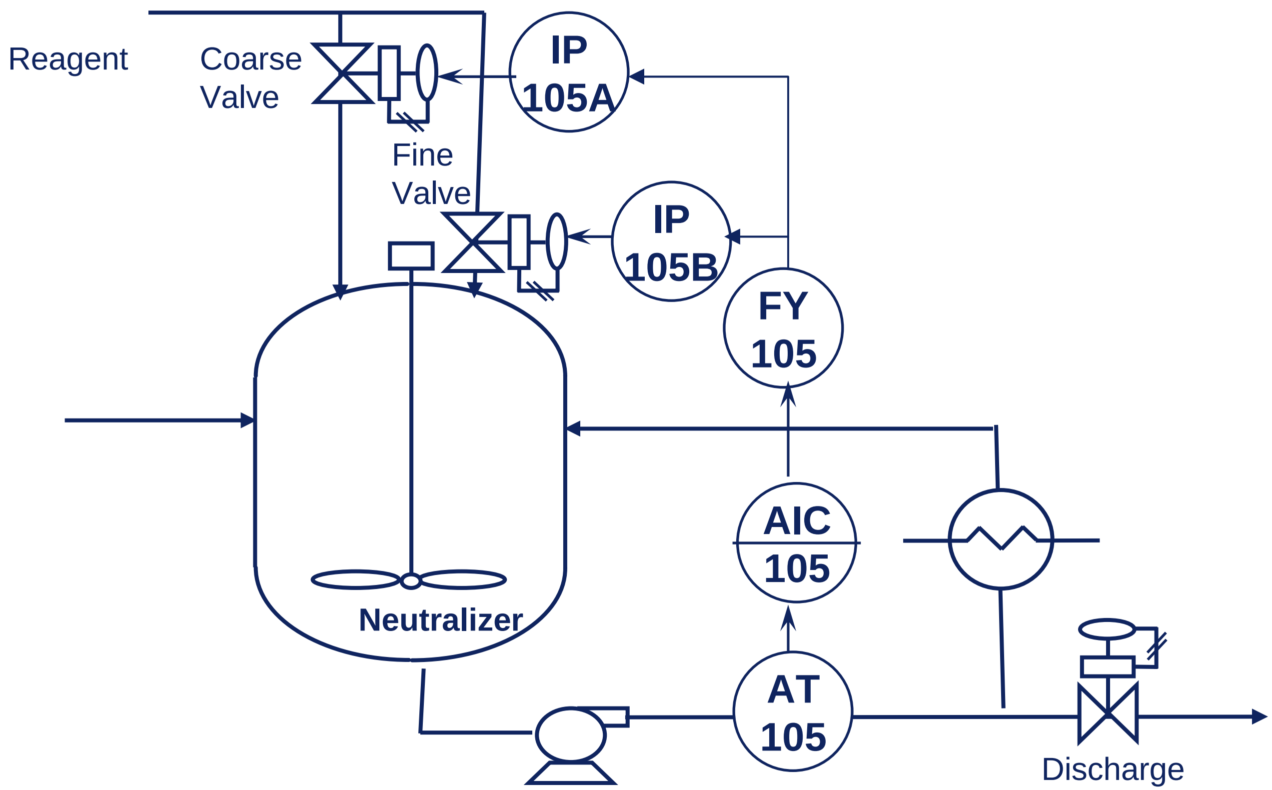
- The SP range associated with each output is defined by IN_ARRAY.
- SP range of outputs may be defined to overlap
- The SP upper end of range must be greater that lower end of range for each output

OUT_ARRAY Parameter

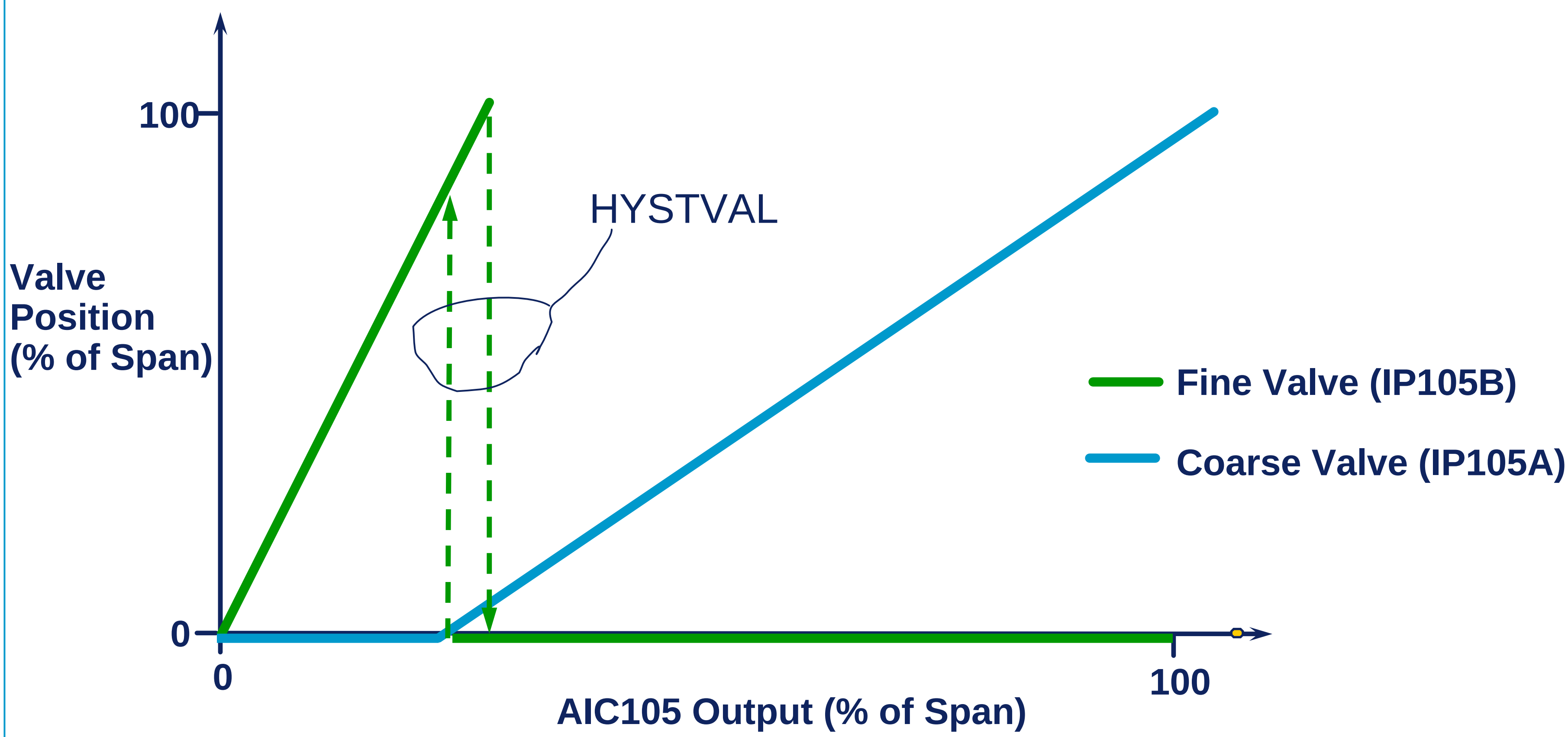


- When SP is outside defined range, then the value at the end of range is used to determine the output.
- LOCKVAL determines if OUT1 value is held if SP is greater that the upper end of range defined for OUT1.
- No restrictions are placed on the output range.

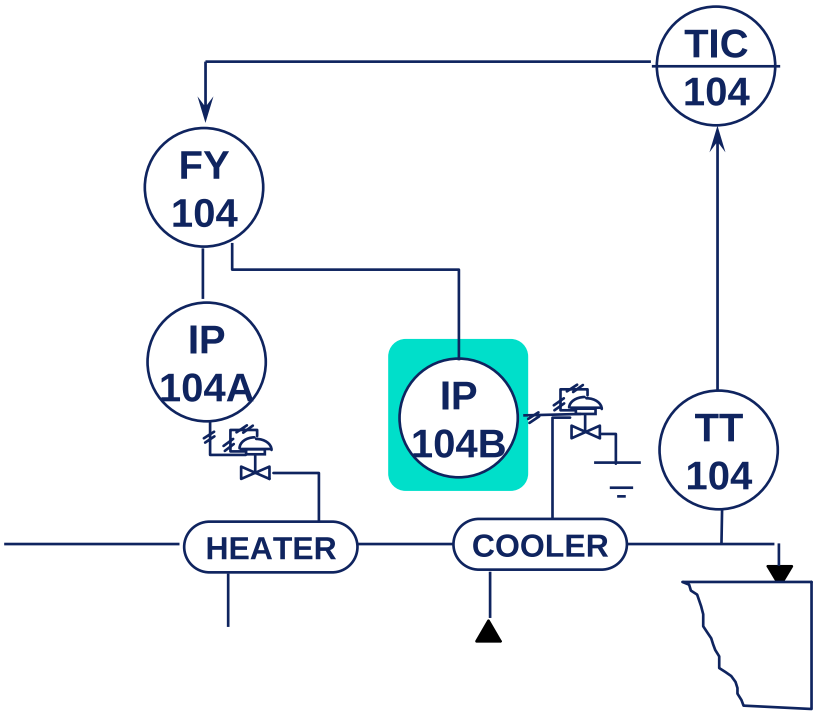
Example - Neutralizer



Split Range Output – Valve Sequencing



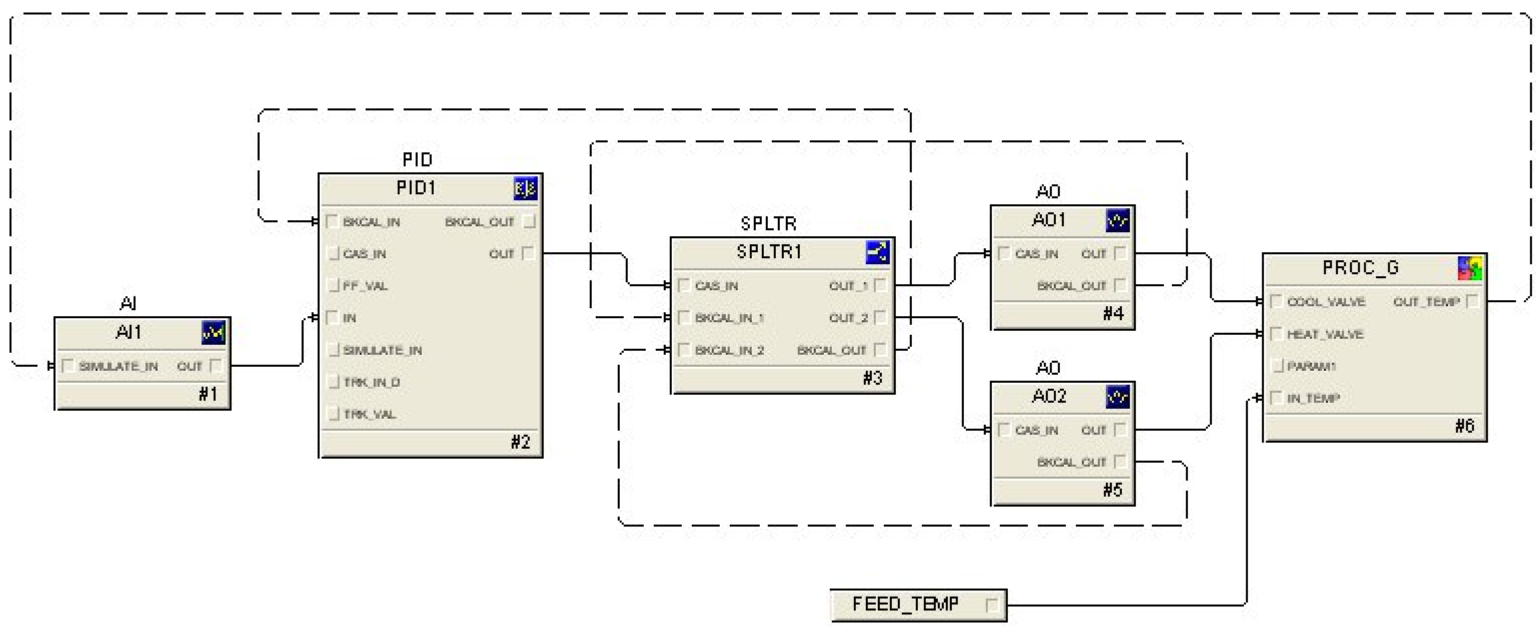
Split-range Control Workshop



Split-range Control Workshop

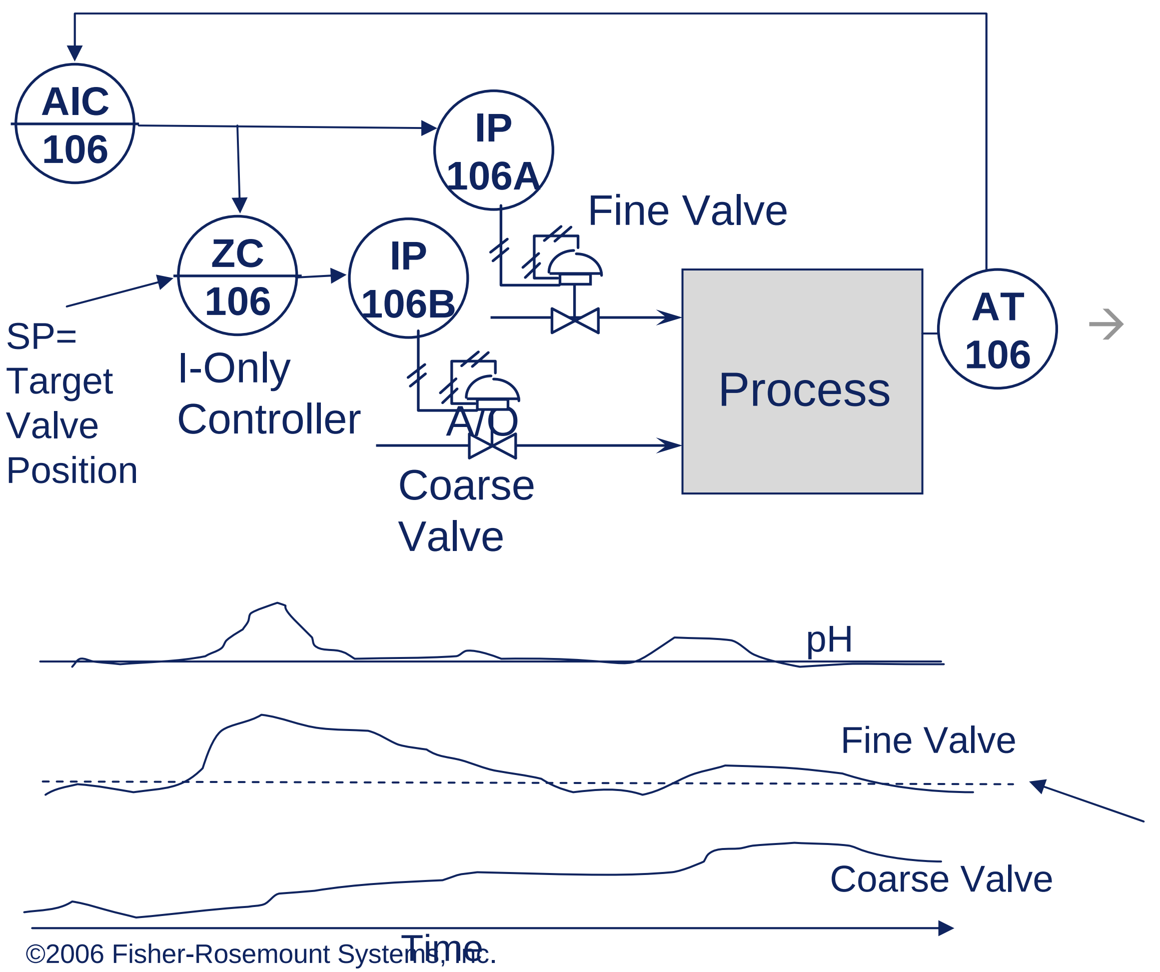
- Step 1. Open the EXAMPLE_G module and go to on-line operation in Control Studio. Change the mode of the Splitter block to Auto.
- Step 2. Change the splitter SP (setpoint) over the following range - 0, 25, 50, 75, 100 - and observe the change in the valves and process outlet temperature.
- Step 3. Change the splitter SP (setpoint) to 50 and wait until the temperature settles to a fixed value.
- Step 4. Make a step change in the FEED_TEMP disturbance and manually adjust the splitter setpoint to get the OUT_TEMP back to its initial value.
- Step 5. Change the splitter mode to Cascade, change the temperature control setpoint and observe the response.

EXAMPLE_G – Split Range



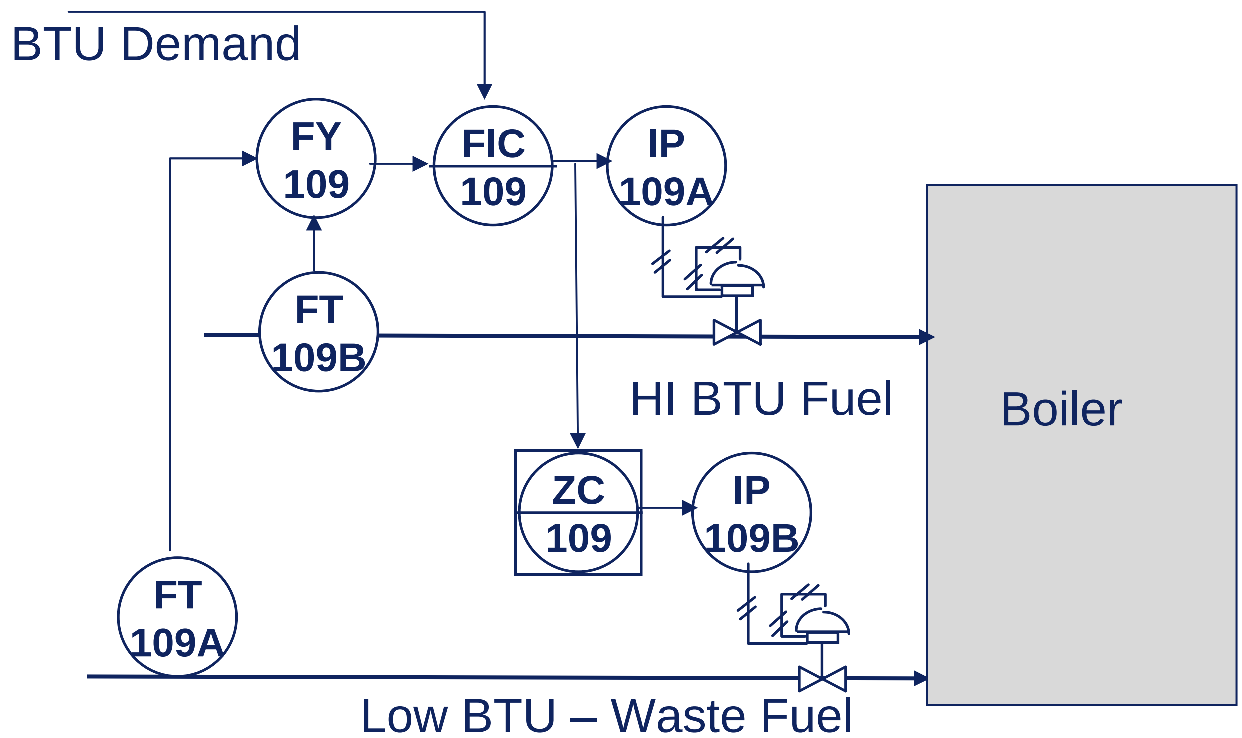
Valve Position Control

pH Example

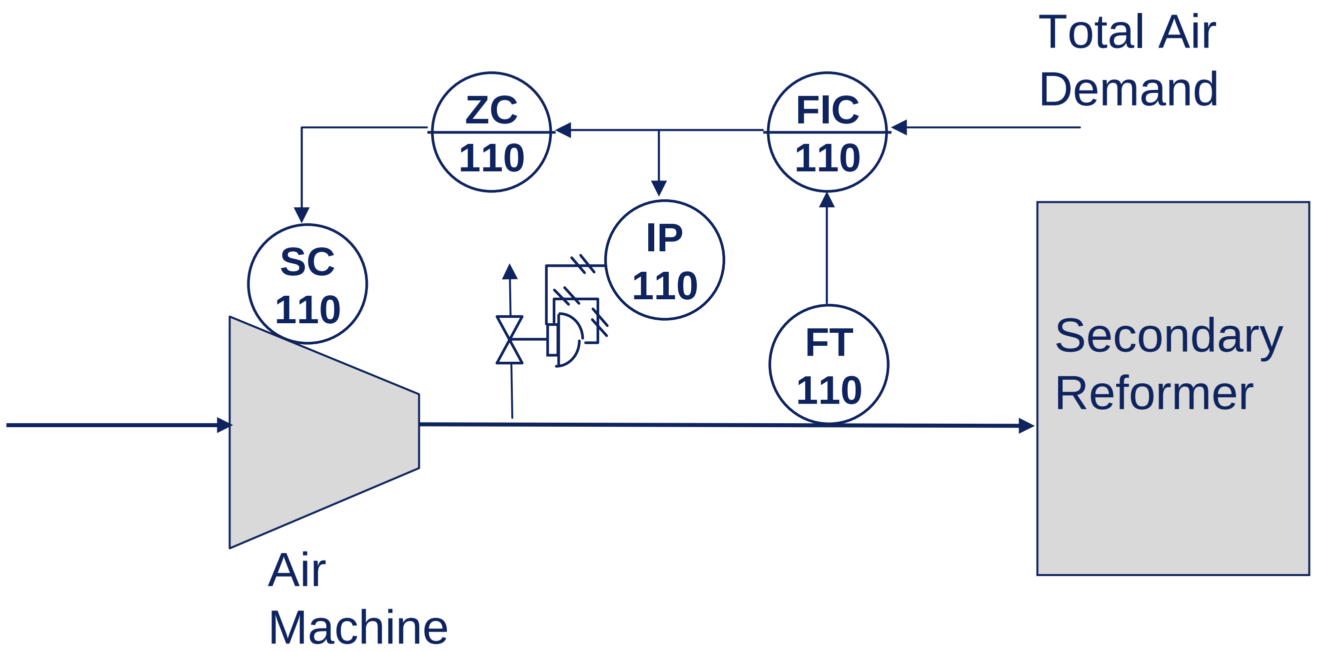


- PID control is implemented using the actuator with finer resolution or fastest impact on controlled parameter
- The actuator with coarse resolution or slower impact on the controlled parameter is adjusted by an I-only controller to maintain the long term output of the PID controller at a given target

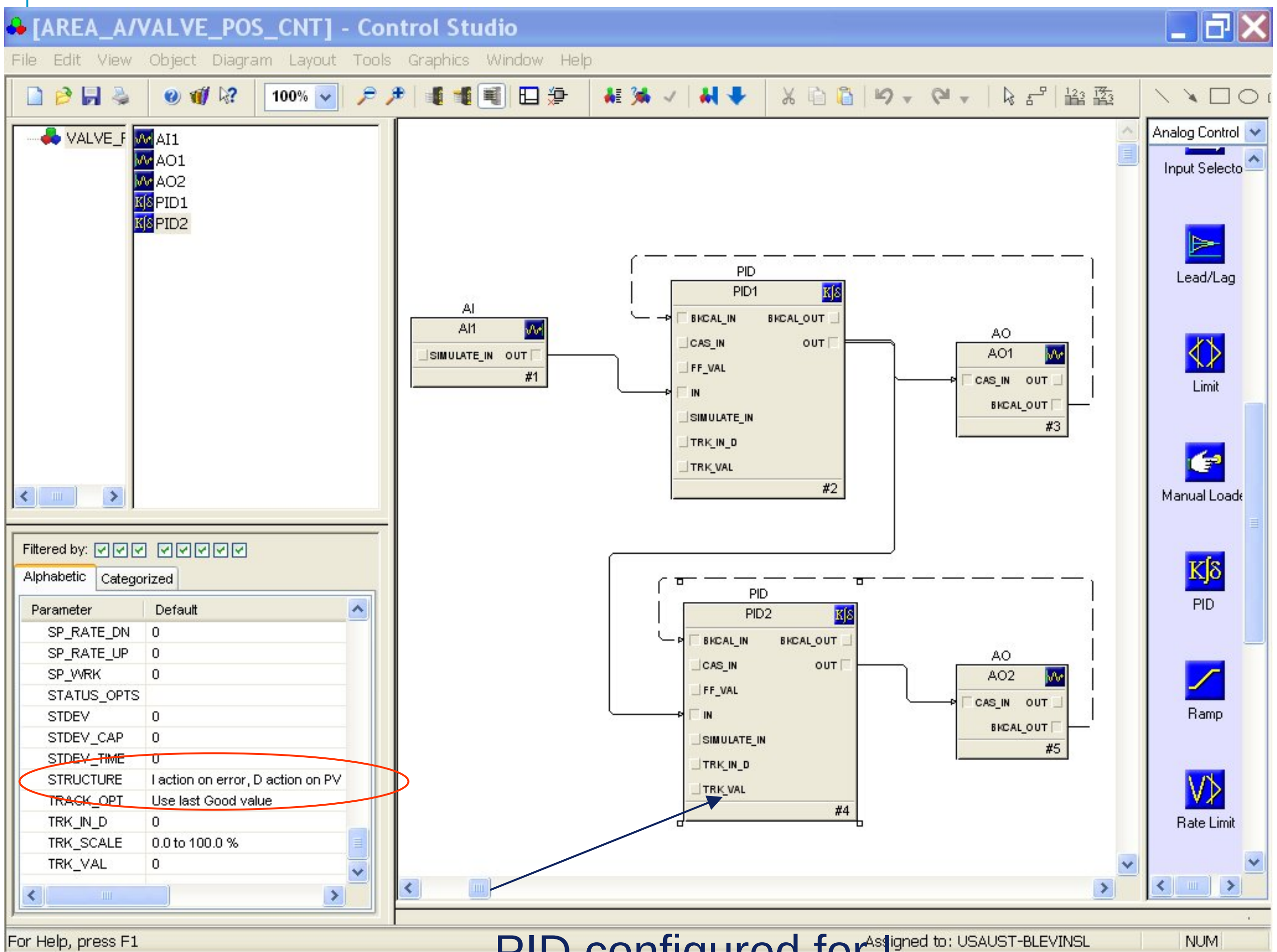
Example -Boiler BTU Demand



Example –Reformer Air Demand



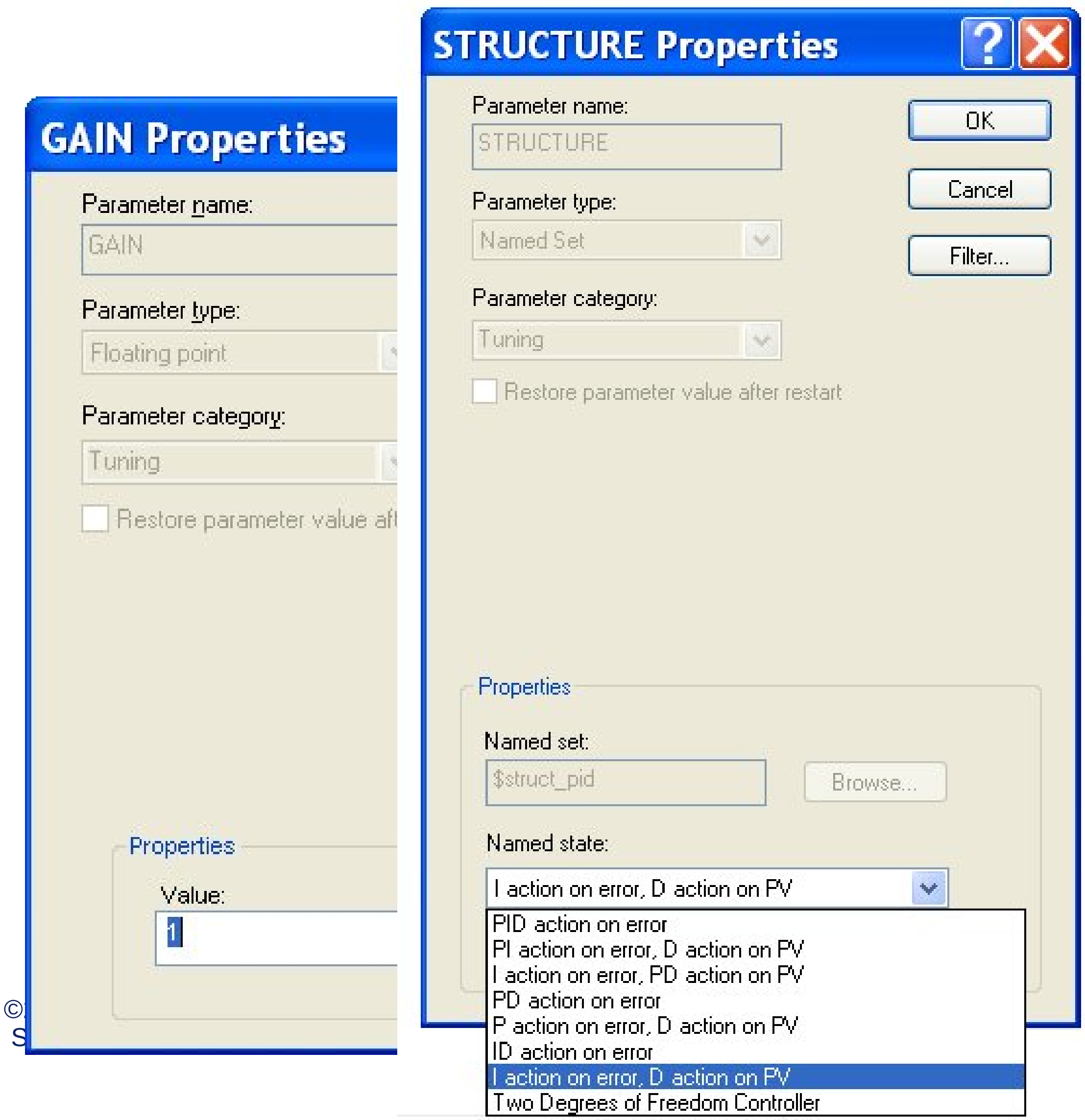
Valve Position Control in DeltaV



PID configured for I-Only control

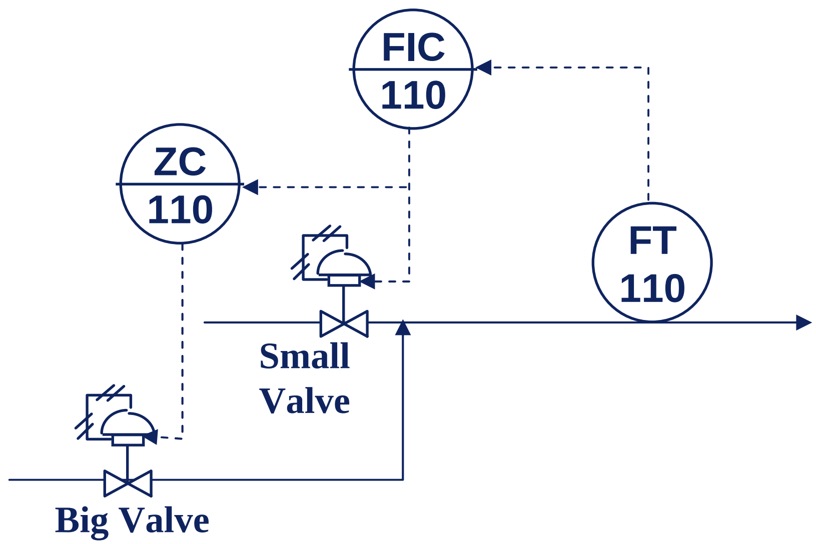
→ The OUT of the PID used for control is wired to IN on the PID block used for I-Only regulation of slower responding or coarse resolution.

Configuring PID for I-Only Control



- The STRUCTURE parameter should be configured for “I action on Error, D action on PV”
- The GAIN should be set to 1 to allow normal tuning of RESET (even though proportional action is not implemented.
- RESET should be set significantly slower than that the product of the PID gain and reset time used for control e.g. 5X slower

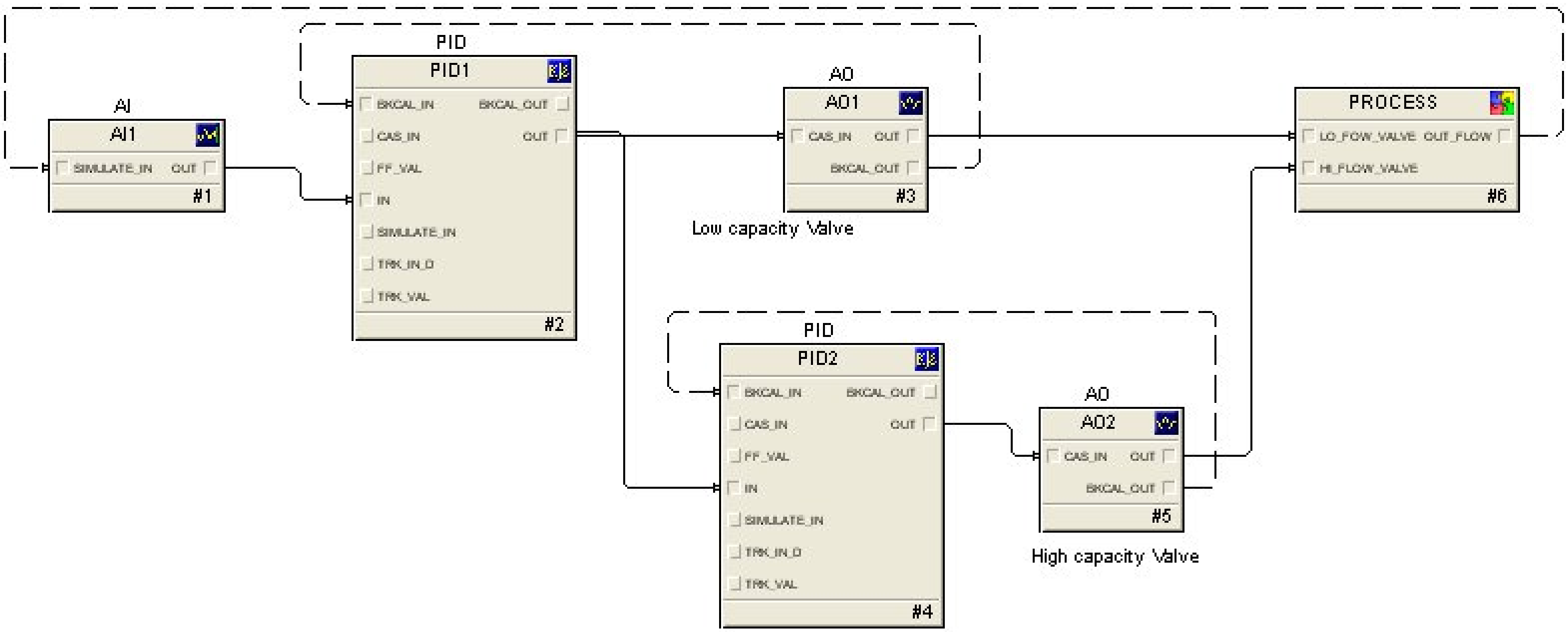
Valve Position Control Workshop



Valve Position Control Workshop

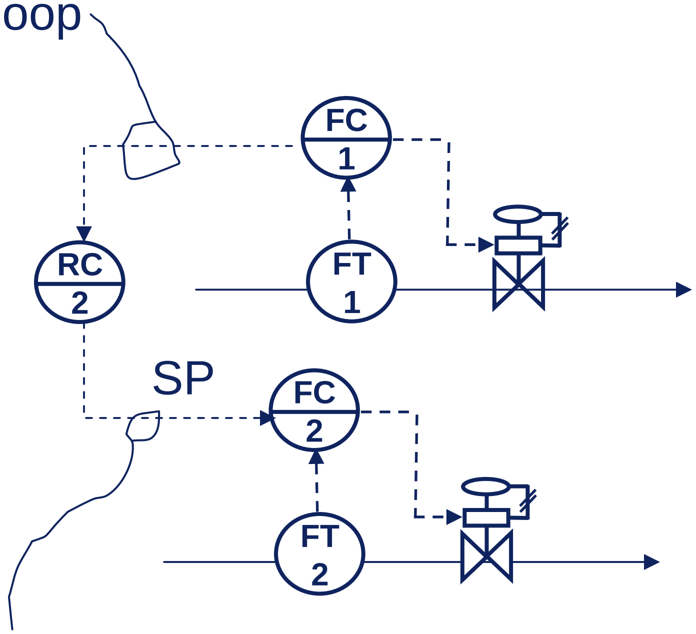
- Step 1. Open the EXAMPLE_H module and go to on-line operation in Control Studio. Change the mode of the flow controller to Auto.
- Step 2. Change the flow control SP (setpoint) over the following range – 40, 50, 60 - and observe the change in the two outputs.
- *Why Is the small valve maintained at 50%?*
- Step 3. Change the SP of the valve position controller and observe the response.

Example H – Valve Position Control



Basis – Ratio Control

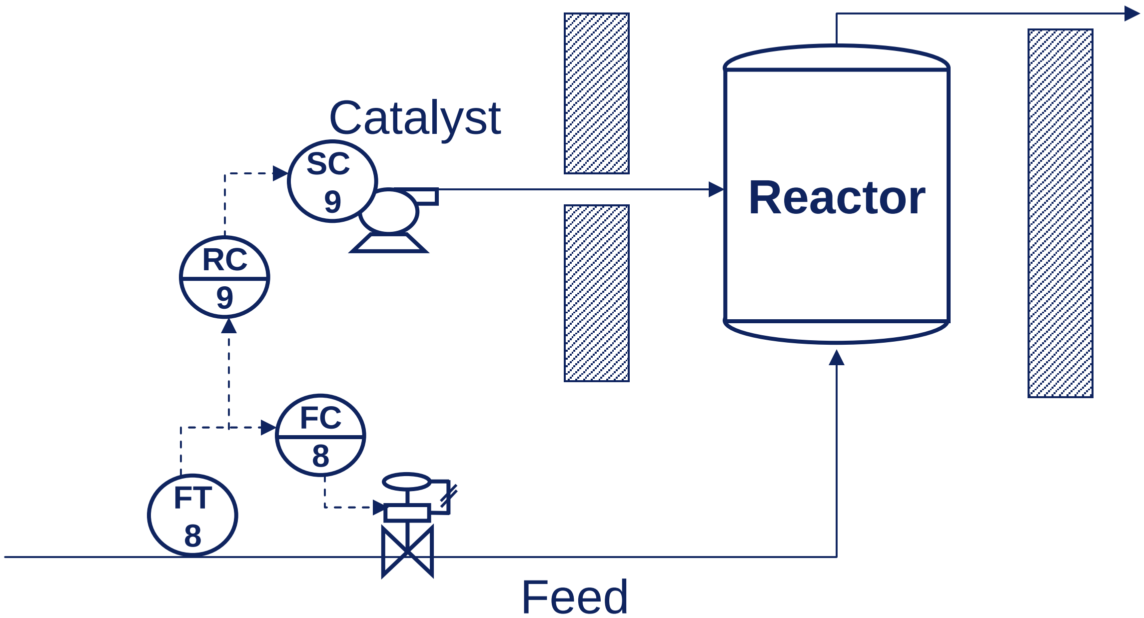
Input = SP or PV of independent loop



SP= (Ratio * Indep Loop Input)

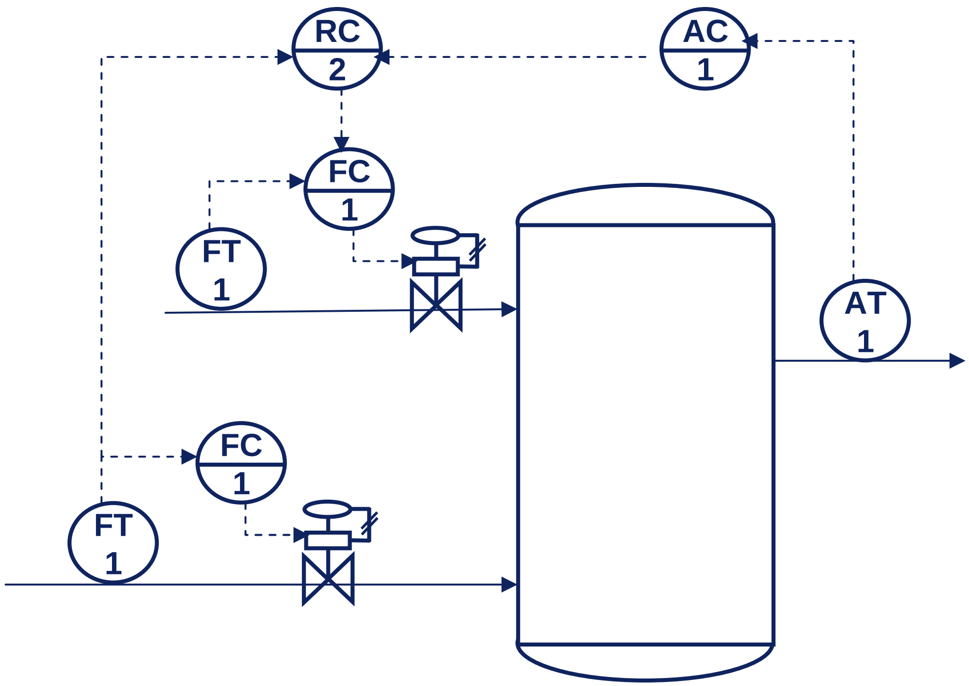
- To fully automate a large process, it is often necessary to provide coordinated adjustment of multiple loops.
- The technique of ratioing control loops is an effective way to provide this coordination.
- Ratio station is used to specify ratio and to calculate setpoint of the dependent loop.
- Ratioing based on the independent loop setpoint provides a noise free remote setpoint but ***will be incorrect if the independent loop can not maintain its setpoint***

Example – Reactor Feed Ratio Control



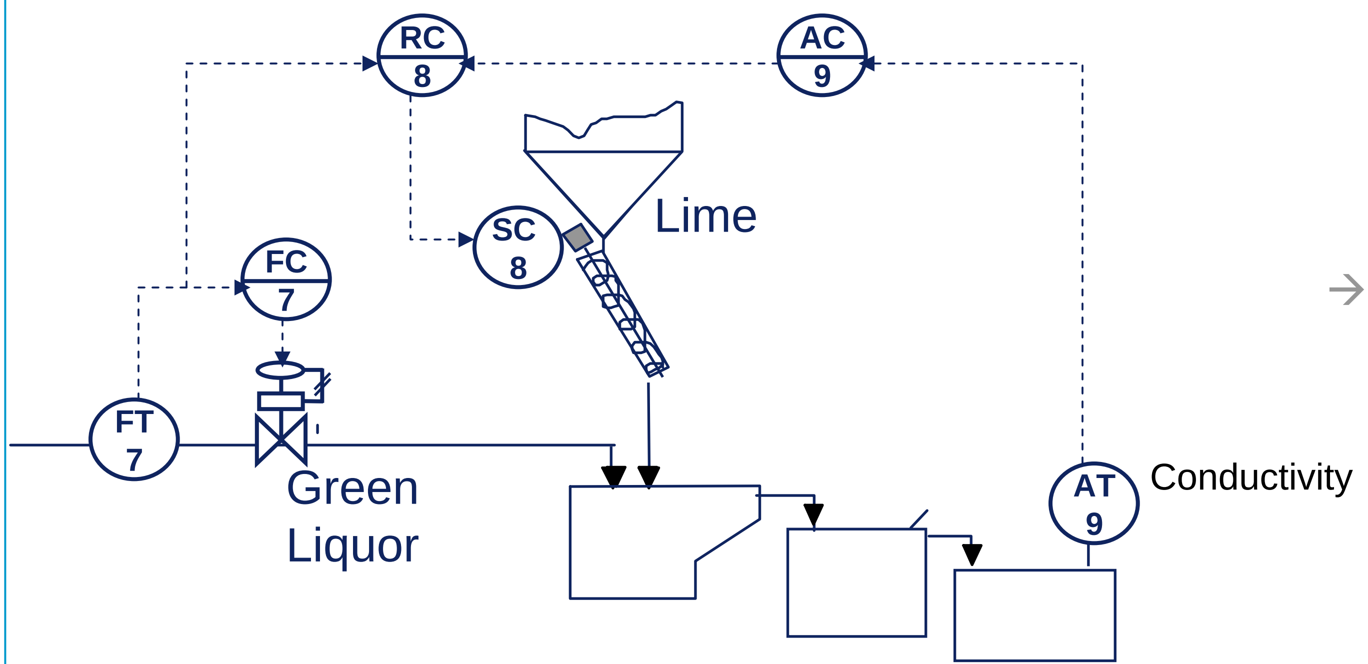
- Catalyst flow must be maintained in correct proportion to the feed flow for correct reactor operation and final product.
- Ratio control automatically provides the correct proportion of catalyst to feed.

Automatic Ratio Adjustment



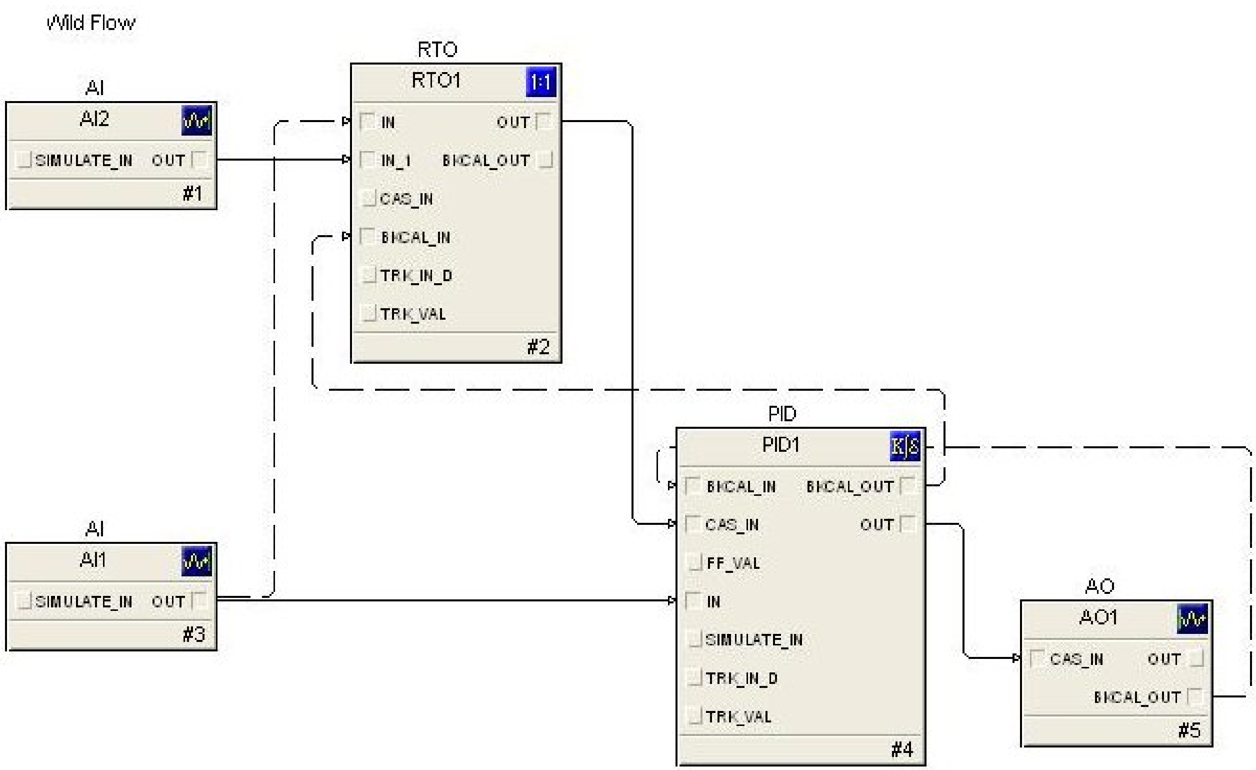
- A process output that indicates the impact of the ratio of process inputs may be maintained at target by using feedback to adjust the ratio target
- To the feedback control, the ratio station and associated flow loops are considered to be part of the process

Example – Slaker Control



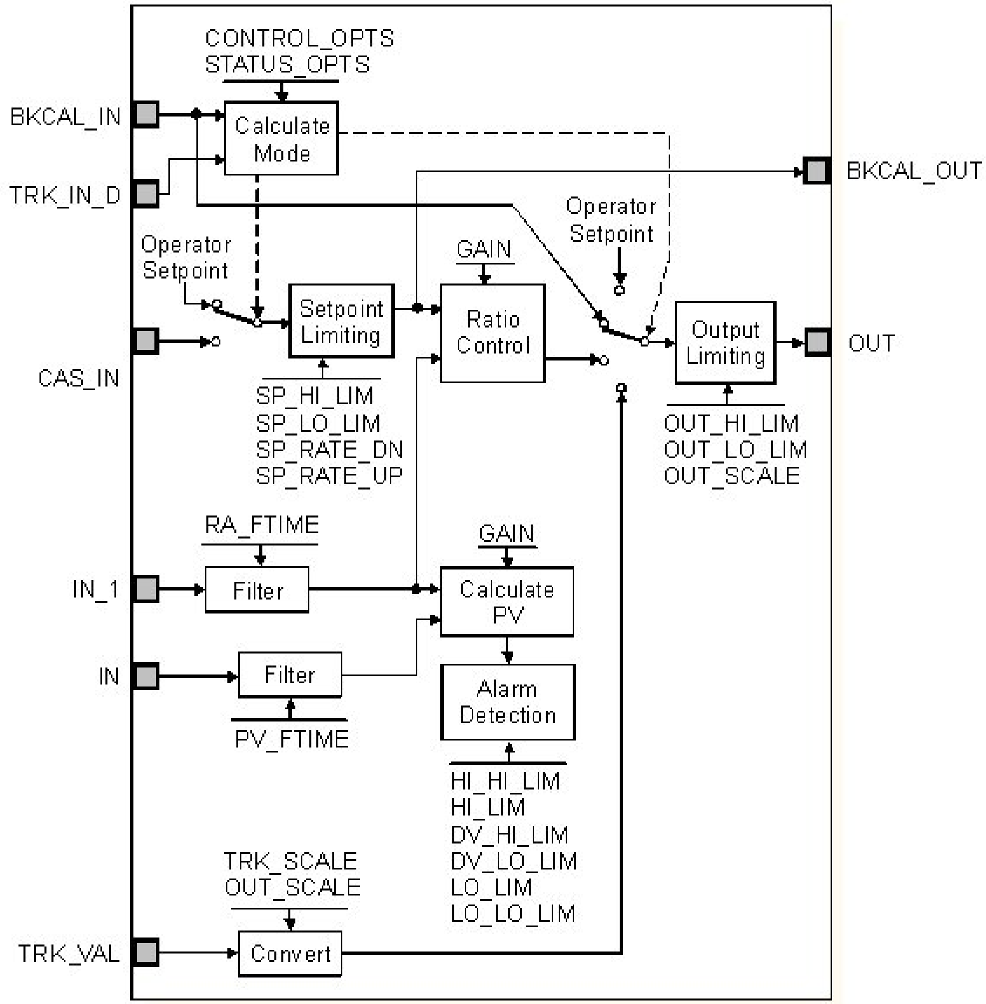
- Effective Alkali. EA, is maintained at target though the adjustment of lime to green liquor flow ratio.
- As green liquor feed is increased, then lime flow is automatically increase in a proportion to maintain the target EA.

Ratio Control in DeltaV

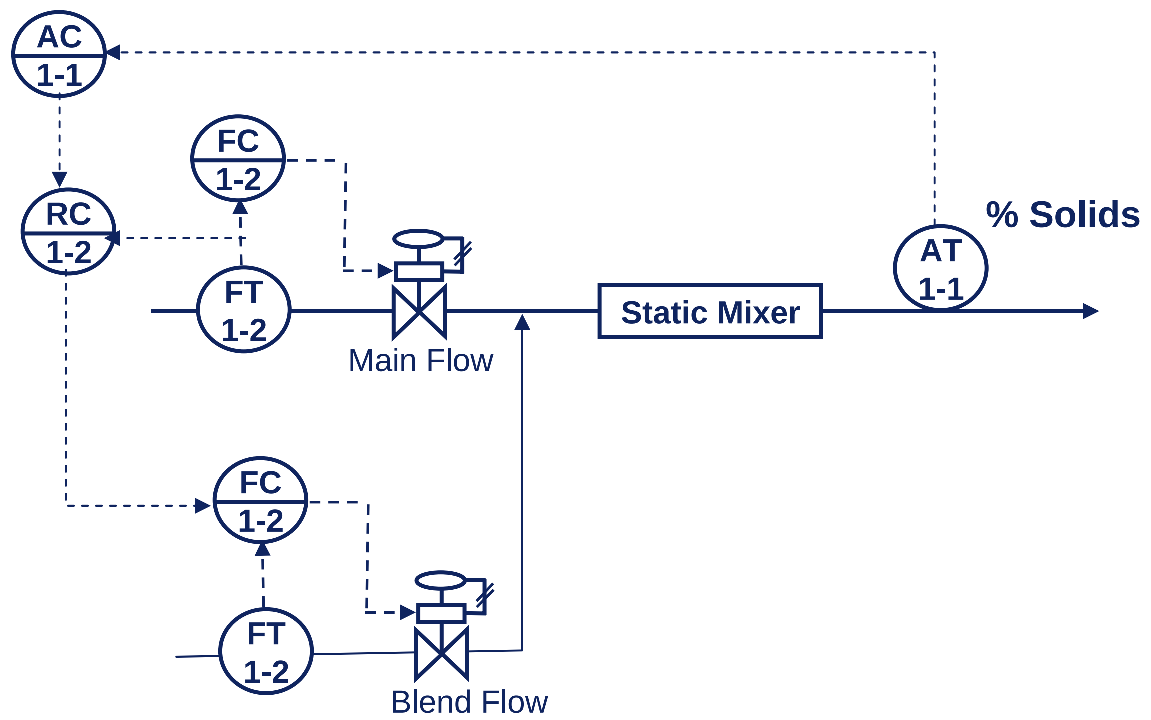


- The Ratio block is used to implement ratio control.
- IN_1 may be a flow measurement (wild flow) or setpoint of another loop
- The true ratio is calculated base on IN_1 and IN and reflected in the ratio block PV.

Ratio Block Function



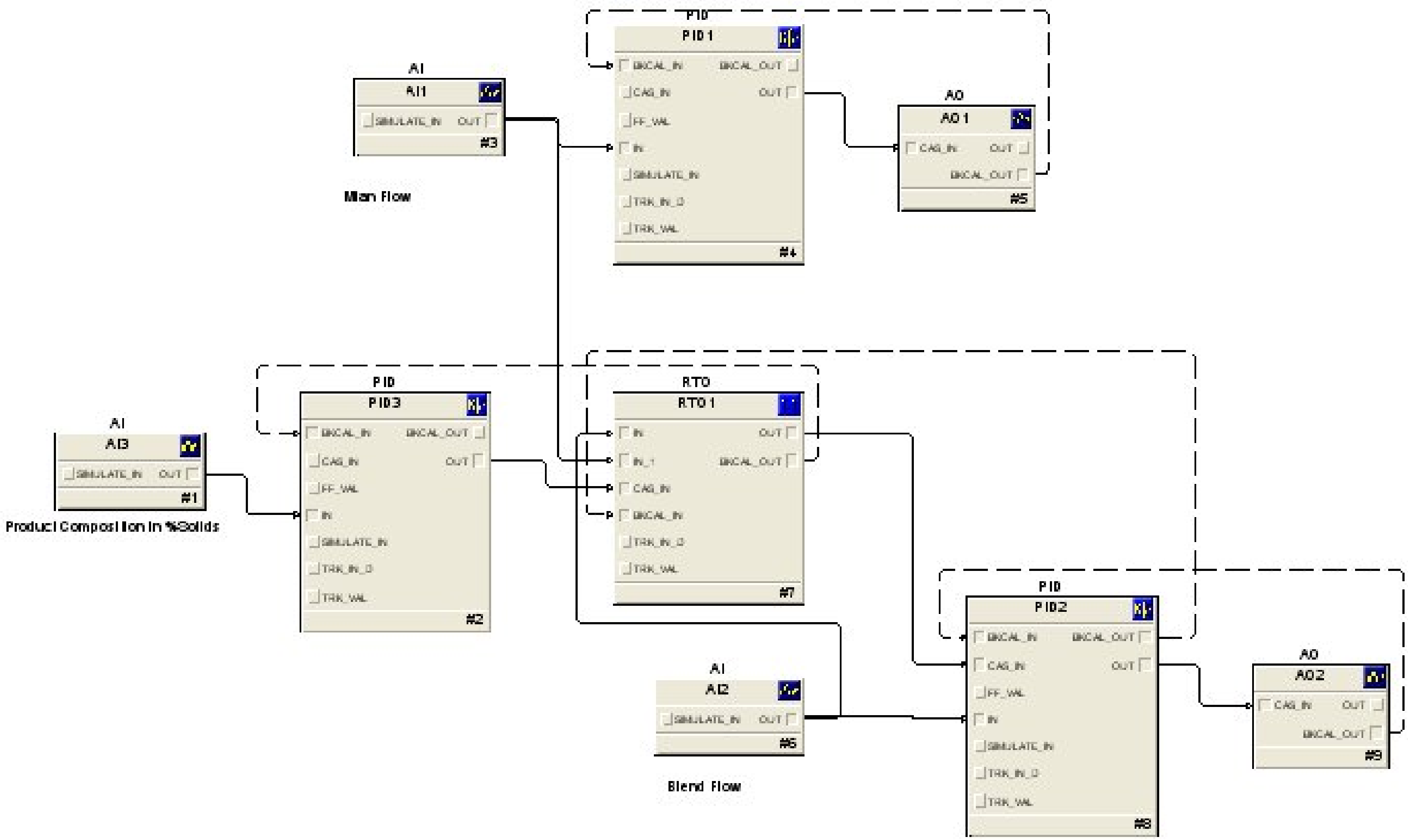
Ratio Control Workshop



Ratio Control Workshop

- Step 1. Open the EXAMPLE_I_CNT module and go to on-line operation in Control Studio. Change the mode of the Ratio block to Auto.
- Step 2. Change the Ratio SP (setpoint) over the following range – 0.3, 0.5, 0.8 - and observe the change in the blend flow and the process outlet concentration. Set the Ratio SP to 0.5 percent and wait for the concentration to settle to a steady value.
- Step 3. Make a step change in the FEED and observe the way the ratio changes the dependent loop. Did the concentration change?
- Step 4. Change the ratio block to Cascade mode. Change the setpoint of the analytical loop to 40% and observe the impact on the ratio setpoint. Does the measured concentration reach setpoint?
- Step 5. Open the EXAMPLE_I_PROC module and examine the process simulation used in this workshop.
- Question: What are the advantages of structuring the process simulation as a separate module? What are the disadvantages of this approach?

EXAMPLE_I_CNT



EXAMPLE_I_PROC