

# Outline

- RP1711/G36 to CDL
- Overview of chiller plant sequences
- Chiller plant control sequence package structure
- Controller architecture
- Generalization and problems - arrays
- How you can contribute
- Library structure demo

# What is a control sequence?

A control sequence is a comprehensive system control algorithm formulated using primarily English with some mathematical expressions.

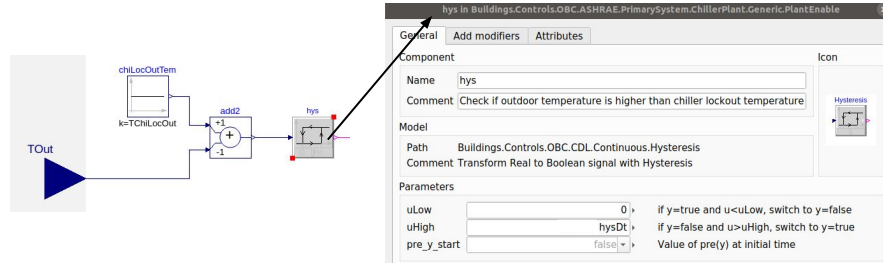
Example English language specification from ASHRAE's primary system control sequence specification document (RP 1711) with the corresponding CDL implementation:

Hysteresis:

*"Control some signal to be:*

*True if  $T_{out} > T_{loc} + 1^{\circ}\text{F}$*

*False if  $T_{out} < T_{loc}$ "*



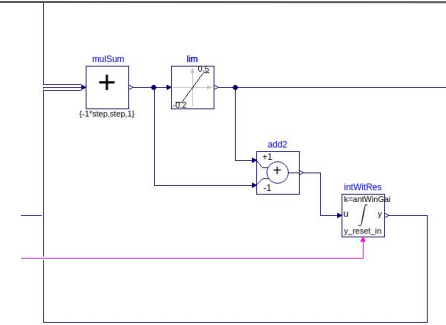
# Lack of explicit definitions in RP1711 sequences

To implement sequences in CDL sometimes one needs to implement additional calculations. These might need to get specified in the Guideline in the future. Often the reason behind it are ALC EIKON features, such as a hysteresis inbuilt in quantity comparison blocks. Two examples:

- When doing stepwise integration with limiters, an anti-windup needs to be implemented:

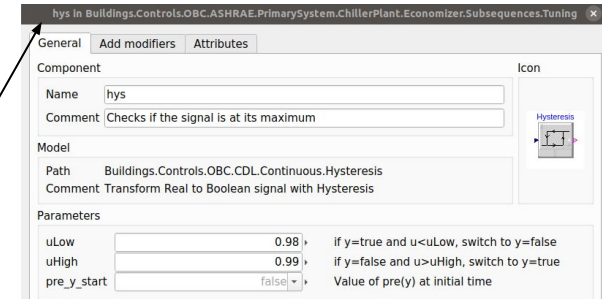
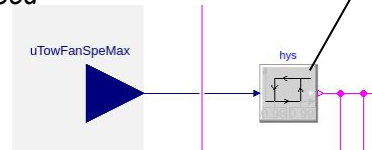
*“Increase “m” by 0.02 when the economizer is disabled if the economizer remained enabled for less than 30 minutes ...*

*“m” shall be limited to the range of -0.2 to 0.5.”*



- When performing quantity comparisons on analogue values (real numbers, for example fan speed), such as greater and smaller than, a hysteresis block needs to be implemented to account for effects such as sensor noise. This is not applicable for time measurement (for example when timing delays). [Click to see more info from user guide.](#)

*“WseTower-MaxSpeed did not decrease below 100% speed”*



# Example chiller plant

## Control intent:

- Supply chilled water to cover cooling demand

## Refrigeration cycle and mechanical constraints:

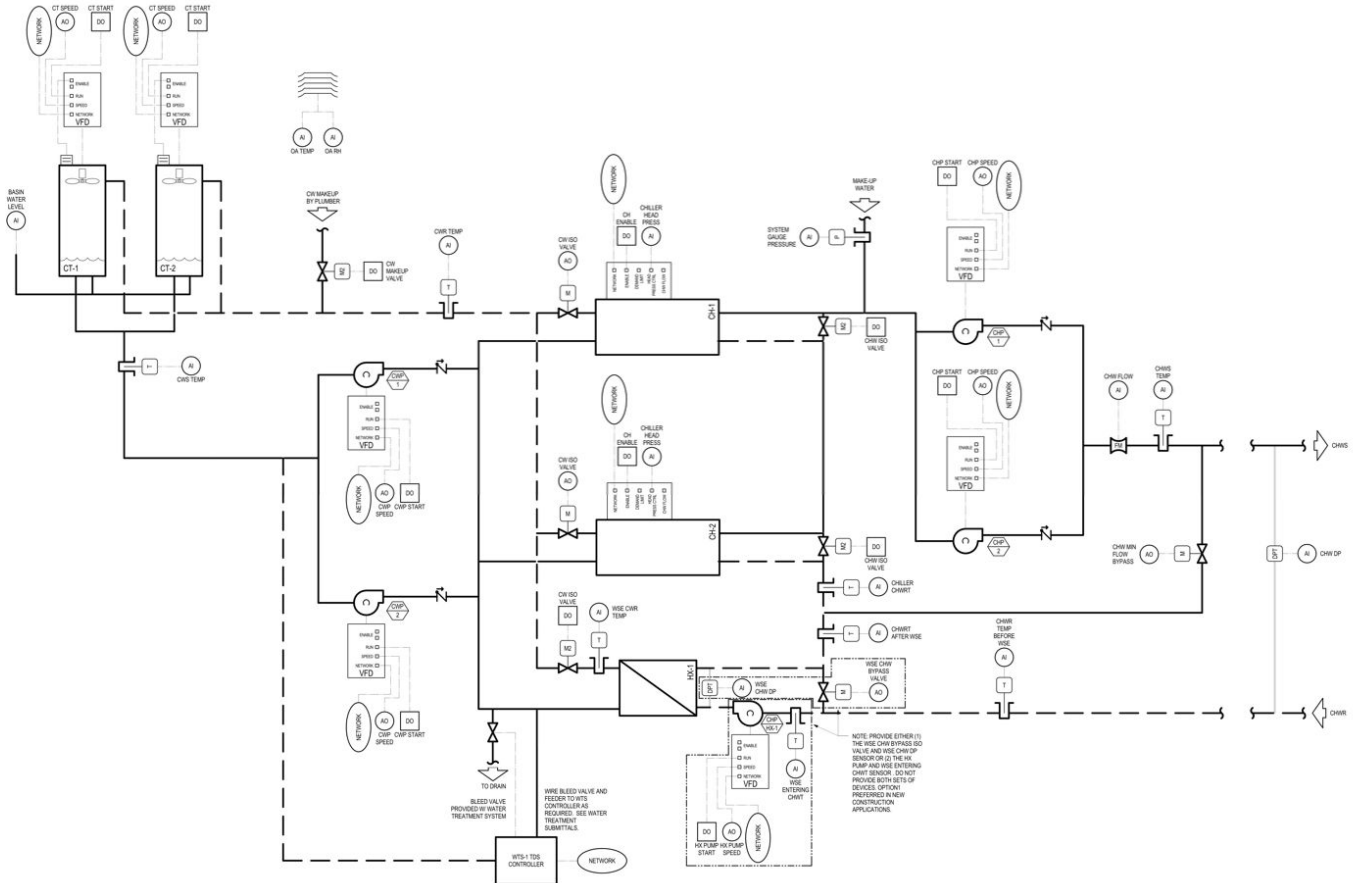
- Minimum lift (controlled on the condenser side)
- Minimum chilled water flow (evaporator side)
- Equipment ramp-up times and system inertia

## Efficiency constraint:

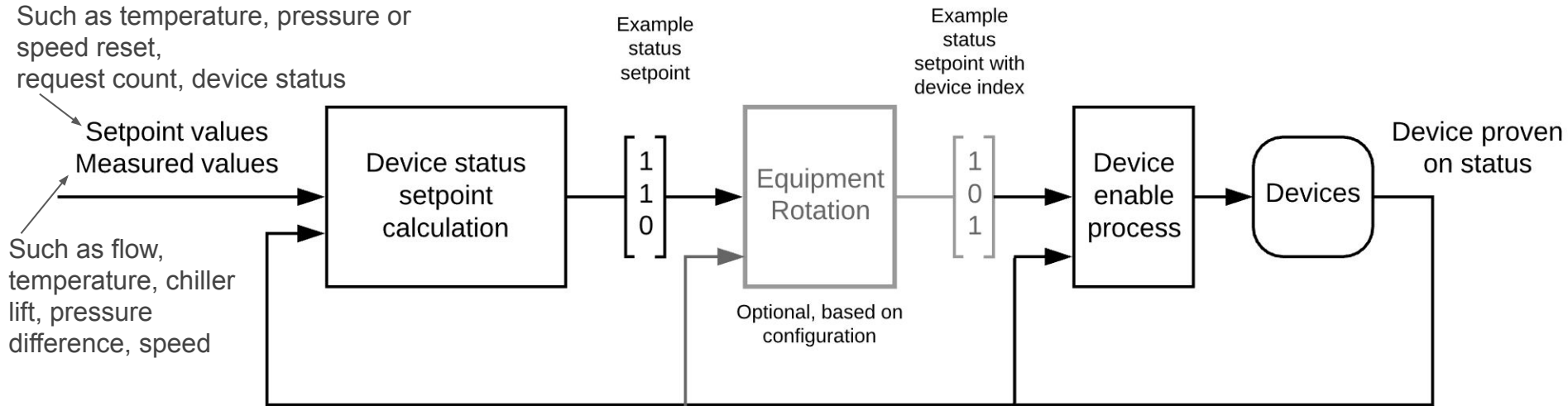
- Minimize energy use

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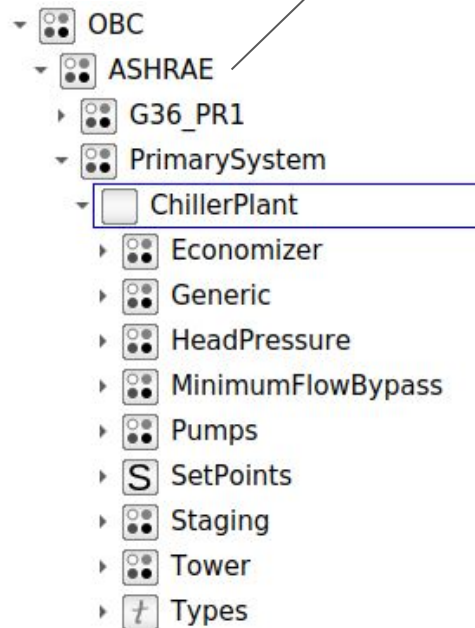
## 6.5 Chilled Water Plants: Series Chillers with WSE, Variable Primary CHW, Variable CW, Headered Pumps



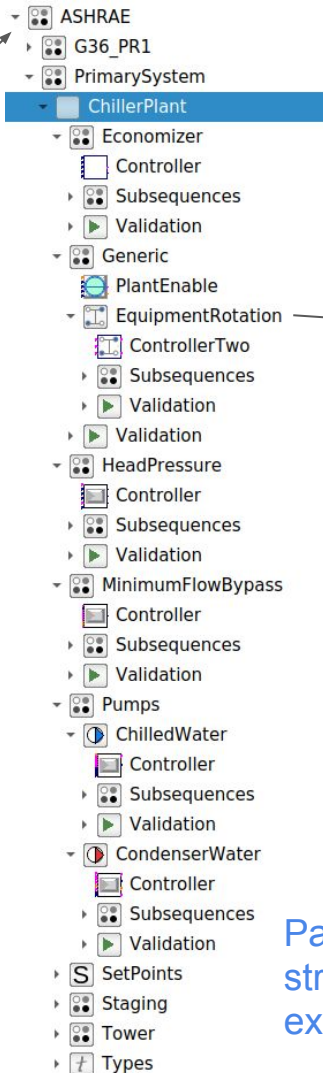
# Overarching approach to device status control



# Library package

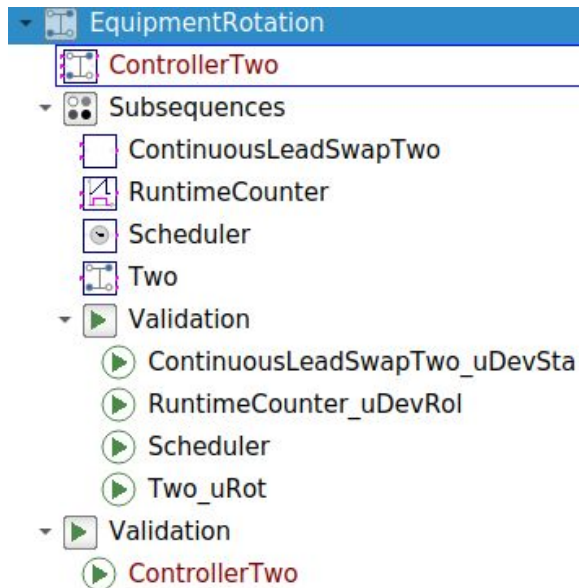


Package structure



Package structure expanded

Subpackage architecture

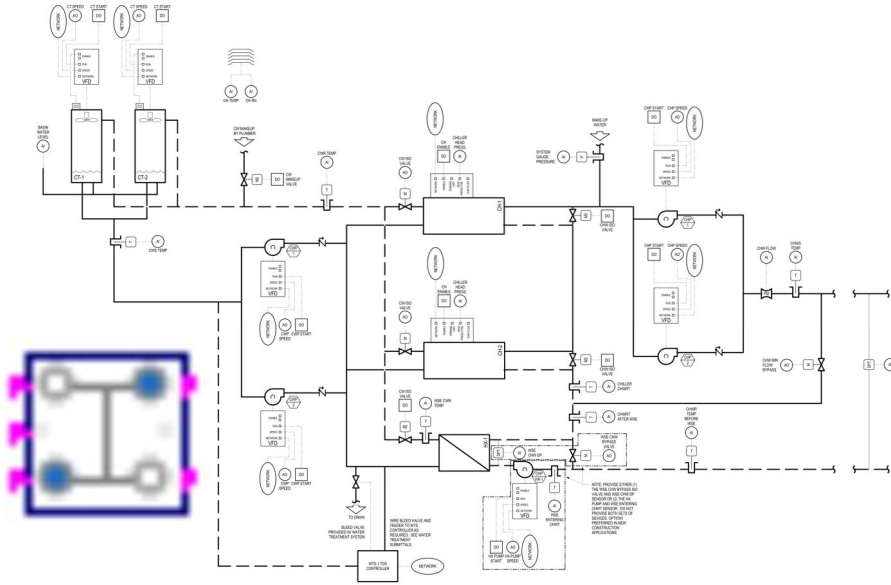


# Controller architecture

## Master controller

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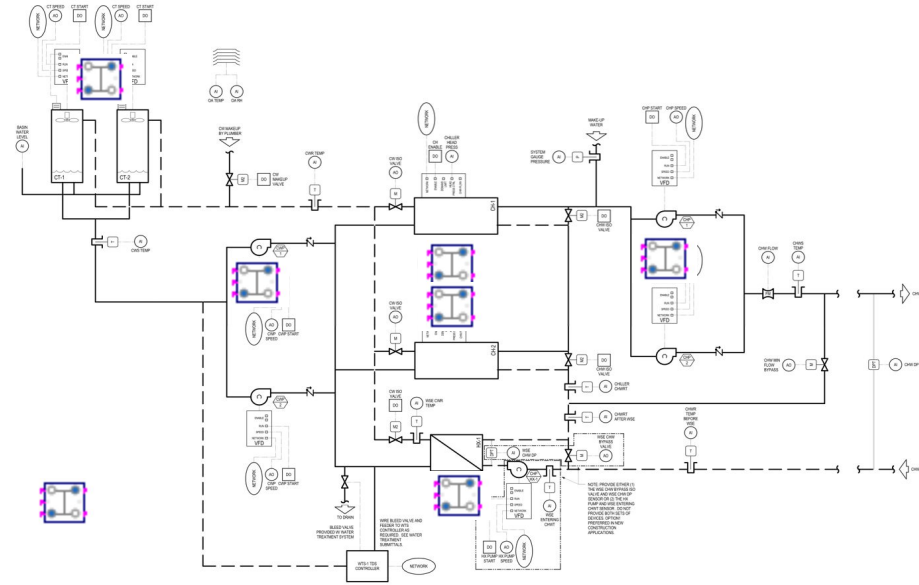
### 6.5 Chilled Water Plants: Series Chillers with WSE, Variable Primary CHW, Variable CW, Headered Pumps



## Dedicated controllers

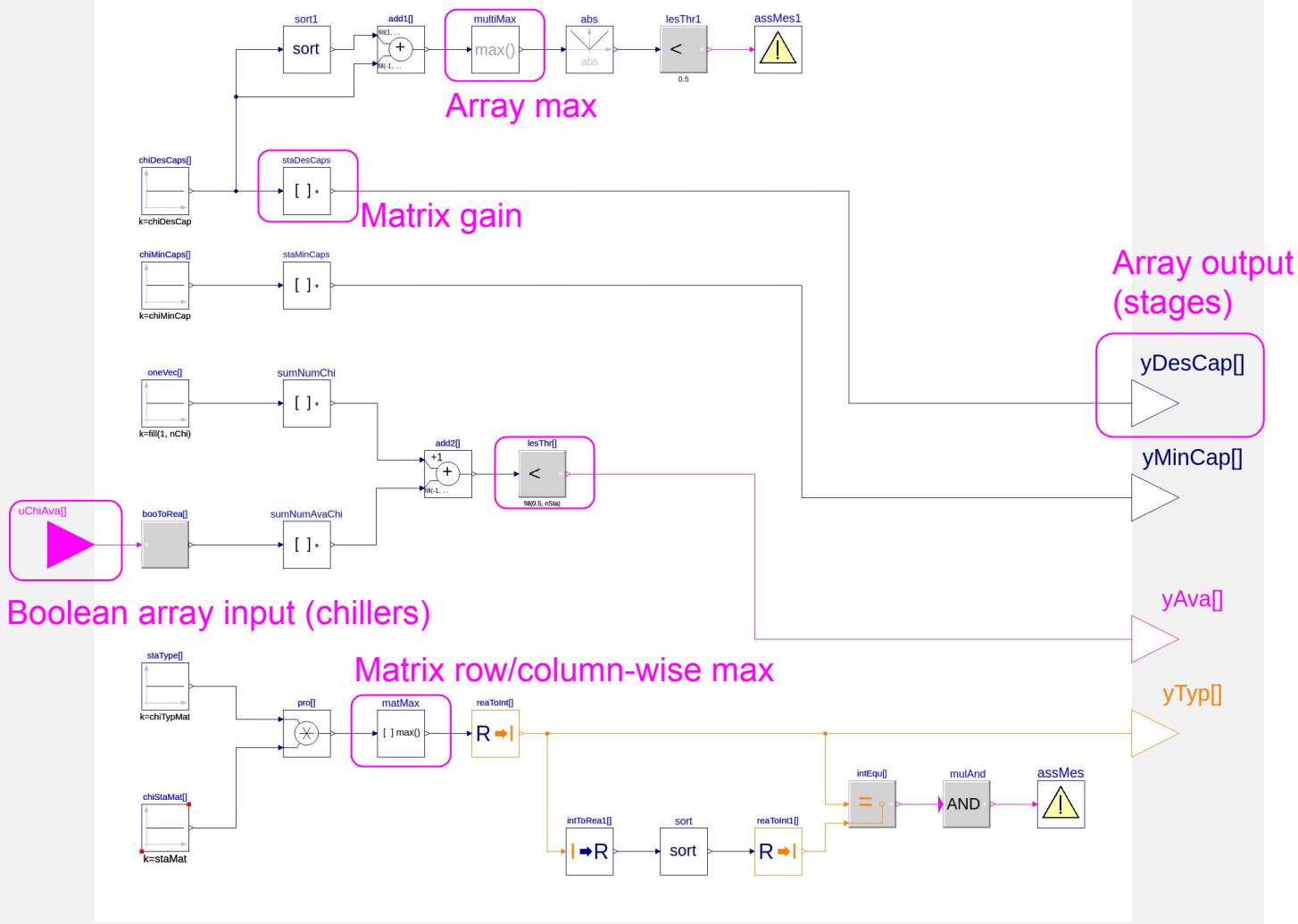
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### 6.5 Chilled Water Plants: Series Chillers with WSE, Variable Primary CHW, Variable CW, Headered Pumps



# Staging configurator:

Involved usage of arrays





# Stage change parameterization: usage of arrays

cha in Buildings.Controls.OBC.ASHRAE.PrimarySystem.ChillerPlant.Staging.Subsequences.Validation.Change

General Add modifiers Attributes

Component

Name cha

Comment Stage change

Model

Path Buildings.Controls.OBC.ASHRAE.PrimarySystem.ChillerPlant.Staging.Subsequences.Change

Comment Calculates the chiller stage signal

Parameters

Array parameters

nSta	3	Number of chiller stages
nChi	2	Number of chillers
staMat	{1,0},{0,1},{1,1}	Staging matrix with stage as row index and chiller as column index
chiDesCap	{500000,1000000}	Design chiller capacities vector
chiMinCap	{100000,200000}	Chiller minimum cycling loads vector
chiTyp	dStageTypes.positiveDisplacement,Buildings.Controls.OBC.ASHRAE.PrimarySystem.ChillerPlant.Types.ChillerAndStageTypes.constantSpeedCentrifugal	Chiller type. Recommended staging order: positive displacement, variable speed centrifugal, constant speed centrifugal
avePer	300	Time period for the rolling average
holPer	900	Time period for the value hold at stage change
upHolPer	900	Time period for the value hold at stage up change
dowHolPer	900	Time period for the value hold at stage down change
anyVsdCen	false	Plant contains at least one variable speed centrifugal chiller
posDisMult	0.8	Positive displacement chiller type staging multiplier
conSpeCenMult	0.9	Constant speed centrifugal chiller type staging multiplier
varSpeStaMin	0.45	Minimum stage up or down part load ratio for variable speed centrifugal stage types
varSpeStaMax	0.9	Maximum stage up or down part load ratio for variable speed centrifugal stage types
hasWSE	false	true = plant has a WSE, false = plant does not have WSE
delayStaCha	15*60	Delay stage change
shortDelay	10*60	Short stage 0 to 1 delay
longDelay	20*60	Long stage 0 to 1 delay
smallTDif	1	Offset between the chilled water supply temperature and its setpoint
largeTDif	2	Offset between the chilled water supply temperature and its setpoint
TDif	1	Offset between the chilled water supply temperature and its setpoint
dpDif	2*6895	Offset between the chilled water pump Differential static pressure and its setpoint
TDifHyst	1	Hysteresis deadband for temperature

Info

Cancel OK

# How you can contribute

- Feedback on controller architecture
- Feedback on usage of arrays
- Sequence implementation review (chiller plant)
- Sequence development
  - Boiler plant
  - Basic blocks such as heat recovery, room thermostat
  - Additional sequences for: radiant heating and cooling, secondary

# Library structure examples

- Contents:
  - Controller/sequence/subsequence models
  - Validation models
- Secondary sequences:
  - Multi-zone VAV and
  - Single-zone VAV
- Primary sequences
  - Chiller plant