TCI

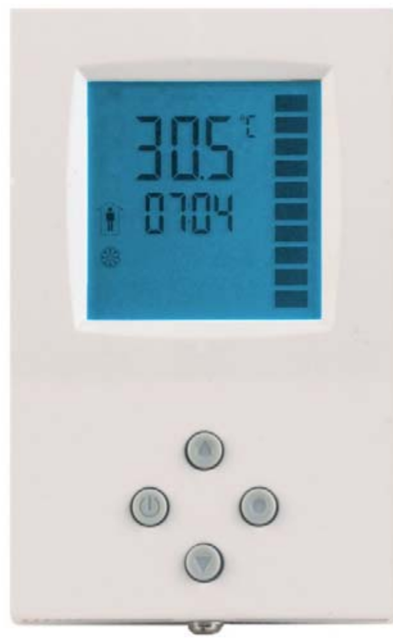
Product Line Introduction
Compact Universal Controller

Contents

- Features
- Product selection
  - Product Range
  - Name logic
  - User interface
- Control Function
  - Binary Control
  - PID Control
  - Cascade Control
  - Set point compensation
  - Set point limitation
- Input Options
  - Signal range and display
  - Alarms
  - Features
- Auxiliary functions
  - Enable controller with inputs
  - Toggle comfort / standby
  - Heating – cooling change
- Output Options
  - Configuration
  - De-humidifying
  - VAV
  - Feedback
- Time Schedules
  - Selection of week days
  - Schedule action
- Applications
  - Boiler control
  - VAV

TCI Pictures

TCI-C



TCI-W-U

TCI-W

Hardware Features

- Wall or Cabinet mounted
- Universal inputs for NTC, 0-10V and 4-20mA control signals
- Analog outputs for 0-10V / 4-20mA
- Binary outputs with Relays or TRIACs
- 10 bit in- and output resolution
- Overvoltage category II
- TCI-W with internal humidity sensor option
- Stand-alone

Software Features

- Alarms on all inputs, flexible action on alarm
- Controllable action on alarms
- Mathematical functions on inputs:
  Average, min / max
- Extended auxiliary functions for enable and heat – cool change
- Control features for cascading, setpoint reset and control loop coupling
- 2 PID and 6 binary sequences per control loop
- Up to 2 independent control loops
- Flexible time schedules for direct control of setpoints, operation modes and outputs

Name Logic TCI

- TCI-Cab = Cabinet mounted
- TCI-Wab = Wall mounted
- a = number of control loops
- b = hardware configuration ID
- -opt = options
  - US = Fits for 2 x 4 inch flush mounting box
  - H = Internal humidity sensor

TCI Product Range

- TCI-C11: 2UI, 1AO, 2DO-R
- TCI-C13: 2UI, 1AO, 2DO-T
- TCI-C22: 4UI, 2AO, 2DO-R, Clock, Schedules

- TCI-W11(-U): 1UI, 1AO, 2DO-R
- TCI-W22(-U): 2UI, 1AO, 2DO-R, Clock, Sched
- TCI-W22-H(-U): As TCI-W22 with rH sensor

Explanation:

UI = Universal Input: NTC, VDC, mA

AO = Analog Output: VDC, mA

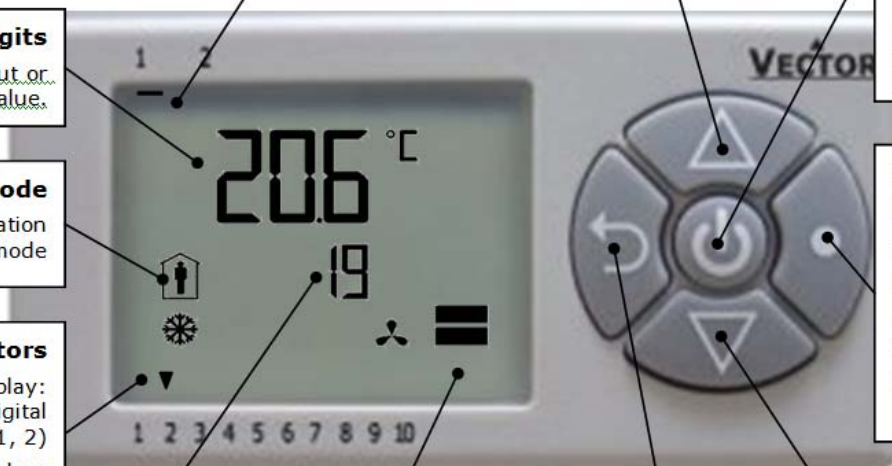
DO-R = Binary Output Relays, Normally open

DO-T = Binary Output TRIAC, Normally open

Control Made Easy

- More flexibility: Free assigning of inputs
- Set point shift for eco/standby mode
- Energy protection: Dead zone may not be negative, constant switching between sequences is prevented
- Delay on auto changeover of heating / cooling sequence (only active if both sequence enabled)
- Cascade options with individual range for reverse or direct sequence of primary loop
- Combination of control loops allows 4 PID and 12 binary sequences per loop.
- Activate sequences based on controller mode (for 2-pipe systems) or demand of control loop. (4-pipe or non temperature related controls)

User Interface



Loop indication

Standard display (no button pressed for 30 sec.): Not visible.

Loop display: Bar at 1 = Loop 1, Bar at 2 = Loop 2

Up

Increment SET POINT

(Parameter setting: SCROLL menu options and parameters)

Center (POWER)

Press < 2 sec.: Toggle STANDBY-COMFORT mode or switch from OFF to ON

Press > 2 sec.: Turn unit OFF. Text OFF displayed with current time (deluxe) temperature (standard)

(Parameter setting: ENTER to select menu option, accept parameter change)

Large Digits

Display of input or parameter value.

Mode

Display of operation mode

Indicators

Standard display: Active digital output (at 1, 2)

Loop display: Active digital stages (at 8,9,10)

Right (OPTION)

Press < 2 sec.: Select Control Loop

Press > 2 sec.: Enter set-up CLOCK, SCHEDULES, H/C

(Parameter setting: ENTER to select menu option, accept parameter change)

Down

Decrement SET POINT

(Parameter setting: SCROLL menu options and parameters)

Small Digits

Display of setpoint, clock or parameter number.

Vertical Bar

(scrolls up/down, 10% resolution)

Left (ESC)

Select Control Loop

(Parameter setting: ESCAPE menu option, discard parameter setting)

Binary Control: Modes

- 3 modes are available
  - Single: Every stage opens on its own
    E.g. Fan control
  - Cumulative: Lower stages stay active, when higher stages open
    E.g. Heater, Compressors
  - Binary: First opens stage 1, than stage 2 and finally stage 1 + 2
    E.g. Heater. Choose 2nd stage double the size of the first stage to get best effects

Binary Control: Features

- More flexibility: Different offset and span for heating and cooling sequences
- Short cycle protection: All stages with hysteresis
- Short cycle protection: Delay on switching (prevents immediate restart after the stage switched on or off)

Hint ☞ The specific offset for binary control sequences makes it possible to first control an analog output or PWM signal using the PID function. Once the PID function is not sufficient, additional re-heat or cooling stages will activate.

PID Control: Features

- More flexibility: Free assigning of inputs
- More options: Offset for heating and cooling sequence, combinations of control loops
- Individual proportional band and integral constant for heating and cooling sequences
- One time interval for integral calculation
- Energy protection: Dead zone may not be negative
- Set point shift for eco/standby mode
- Delay on auto changeover of heating / cooling sequence (only active if both sequence enabled)

PID: Parameters

- 3 parameters are required to define the PID control function
  - X_P: Proportional band
  - K_I: Integral gain
  - T_I: Measuring interval

PID: P-band, X_P

- X_P: Proportional Band
- Definition: The input error required to generate 100% output
- Kp = 100/Pband
  - The larger the P-band, the more stable the control but the greater the offset
  - The narrower the P-band, the less stable the control but the smaller the offset
  - Target: Find the smallest acceptable P-band that will always keep the process stable with minimum offset

PID: IAT

- Integral Action Time: IAT
  - IAT is the time it takes for the integral action to equal the proportional action.
  - The values required for T_I and K_I depends on the reaction time of the control loop.
  - If the Integral Action Time (IAT) is chosen too short, the control loop will become instable and oscillate.
  - Control loop stability is achieved, since the IAT depends in part on ΔW. The smaller the difference, the larger the IAT = stability!
  - ΔW=set point difference
  - T_1= Measuring Interval
  - K_1= Constant

$$IAT = \frac{T_I \cdot 100}{\Delta W \cdot K_I}$$

PID: Examples

- Recommended PID settings for different applications
- Temperature Control,
  Control reset time 5 Min for ΔW = 2K
  K_1 = 1.0, T_1 = 3s, X_P = 5K
- Humidity Control,
  Control reset time 20 Min for ΔW = 10%
  K_1 = 0.5, T_1 = 60s, X_P = 30%
- VAV control:
  Reset time 100 s for ΔW of 10% (depends on actuator)
  K_1 = 0.5, T_1 = 1s, X_P = 0%

VECTOR

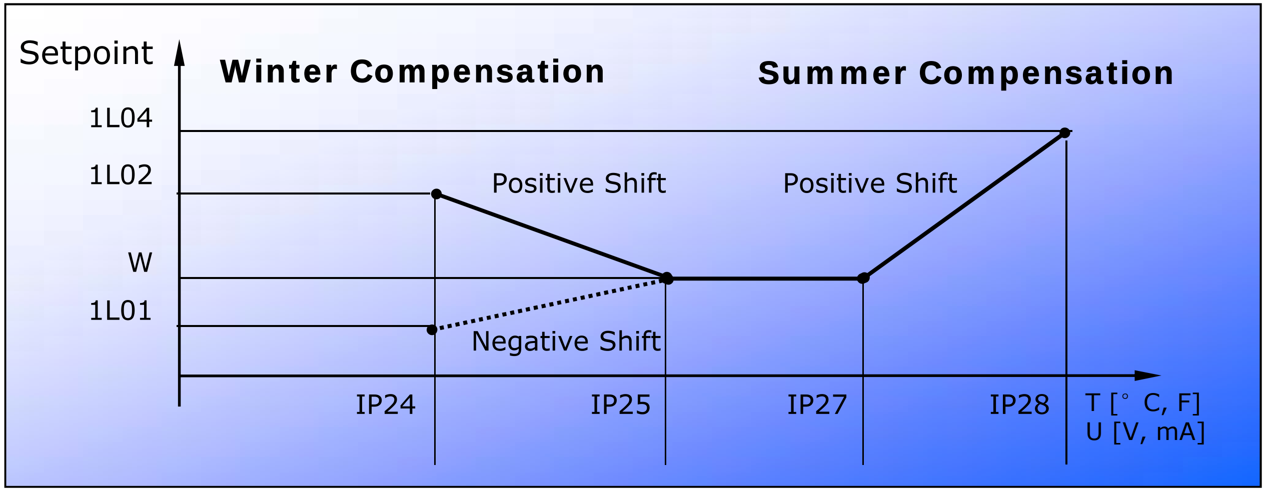
Cascade Control

- The output of the primary controller defines the set point of the secondary controller
- Use the cascade parameter of the secondary control loop, to define the cascade control function.
- The set point of the secondary loop may be defined by the output of the reverse sequence, the direct sequence or both sequences of the primary loop.
- The output of the primary heating sequence will be spanned between low and high heating set point limits of the secondary loop
- The output of the primary cooling sequence will be spanned between the low and high cooling set point limits of the secondary loop

Cascade example

- Application Example: VAV control:
- Primary loop = temperature loop
- Secondary loop = Air flow input on loop 2
- Damper actuator output on reverse PID sequence of loop 2.
- Cascade on both heating and cooling sequences of loop 1: Parameter 2L06 = 3
- Set point limits of loop 2 depending on VAV needs:
  - Heating Min = 15% Cooling Min = 15%
  - Heating Max = 50% Cooling Max = 90%

Set point compensation



- Shift the set point either towards the set point minimum (negative shift) or the set point maximum (positive shift) depending on a compensation input signal
- Define the limits of the compensation input when the shift shall start and end.
- Define if the shift shall be positive (towards set point maximum) or negative (towards set point minimum)

Compensation Example

- Summer Winter Compensation based on Outside temperature
  - Select temperature input as compensation input IP22 = OFF
  - If –5 < TEXT < 10 shift set point towards SP Min Heating
    IP 23 = OFF, IP24 = –5, IP25 = 10
  - If 25 < TEXT < 40 shift set point towards SP Max Cooling
    IP 26 = ON, IP 27 = 25, IP28 = 40

Inputs

	TCI-C11/13	TCI-C22	TCI-W11	TCI-W22
Input 1	UI1	UI1	T int.	T int.
Input 2	UI2	UI2	UI1	UI1
Input 3		UI3		UI2
Input 4		UI4		H int.

- Low pass filtering of inputs. Select number of samples taken for filter.
- Select 0-10V / 0-20mA or 2-10V / 4-20mA input types
- Choose display or universal input: Select unit and multiplier. It is now possible to convert 0-100% input to display values of -500 to 9999.
- 10 bit resolution: 1024 steps

VECTOR

Input Options

- Auto-adaptation of resolution. Depending on the display range (Display max – Display min) the resolution changes:
  - Display range < 25: Resolution = 0.1
  - Display range > 25 < 125: Resolution = 0.5
  - Display range > 125: Resolution = 1
  - Note: Resolution is doubled for Temperature inputs in Fahrenheit mode
- All inputs can be calibrated

Input Functions

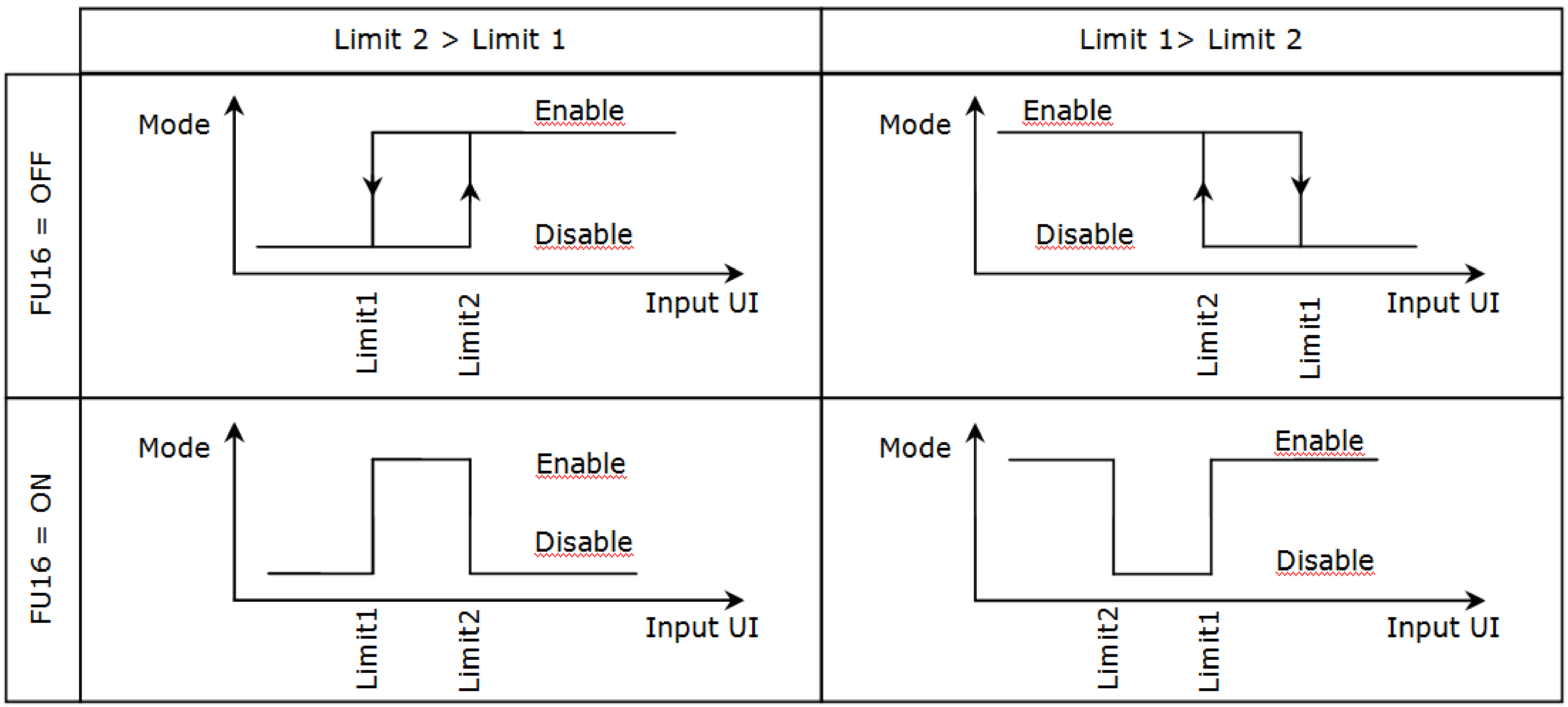
- Combine different inputs with the mathematical functions:
  - Average: Sum of UI values divided by number of UIs
  - Minimum: Lowest UI value from number of UIs
  - Maximum: Highest UI value from number of UIs
- Select on all involved inputs the desired function.
- Condition: All inputs must be of same range.
- The largest input will carry the signal of the function. The other involved inputs carry their measured values.
- Example: UI1, UI2, UI4 set to average. When using UI4 as input to a control loop, the average value of UI1, UI2 and UI4 is taken. If UI1 is chosen as input, only the measured value of UI1 is shown.

Aux Functions: Enable

- Enable the controller based on input value by setting enable and disable limits.
- Disable the controller based on alarms
- Decide if it is allowed to manually start the controller
- Delay for switching on or off
- This allows to start a controller and give it time to reach the targeted operation values. If the operation limits are not reached within the allowed time, the controller will switch off. For example: Pressure in a duct, Temperature for a burner, etc.

Aux Functions: Enable

- Full Flexibility to enable the controller based on input value:



VECTOR

Aux Functions: Heat/Cool

- Changing the heat – cool mode of the controller based on input value by setting limits or tie it to a control loop.
- Limit 1 < Limit 2: Heating is activated when temperature drops below limit 1. Cooling is activated when temperature rises above limit 2. Use this for outdoor sensor.
- Limit 1 > Limit 2: Heating is activated when temperature rises above limit 1. Cooling is activated when temperature drops below limit 2. Use this for supply media sensor.
- Set a delay time to avoid frequent switching

Outputs

- Analog Outputs
  - One output except for TCI-C22 = 2 AO
  - 0..10V/0..20mA or 2..10/4..20mA
  - Other ranges are selectable in SW
- Binary Outputs
  - Two outputs
  - Either one floating output or two binary outputs
  - Relays except TCI-C13: TRIACs

Analog Output

- Assign output to either loop 1 or loop 2
  - Heating sequence only
  - Cooling sequence only
  - Heating and cooling sequence
- Assign output to dehumidifying function
  - Maximum demand of loop 1 and loop 2, cooling sequence
- Assign output to manual override
  - Great for on site testing and manual control, choose 0…10, 0…100 or on/off modes
- Show the value of inputs or set points on the analog output
  - Use as transmitter, signal converter or BAS interface
  - Choose output range

Analog Output VAV

- Select actuator signal type 0-10V / 0-20mA or 2-10V / 4-20mA
- In case control loop is selected it is now possible to choose different minimum and maximum settings for the analog output.
- This can directly be used to adjust minimum and maximum flow settings for heating or cooling mode.
- For non control loop settings the minimum and maximum settings of the heating sequence may be used.

AO: Feedback feature

- Select temperature inputs or set points and define signal range. E.g. 0…50ºC
- Analog status control for BAS:
  - Choose signal minimum of 20% and maximum of 80%
  - If operation mode is OFF, output will be 0%
  - Set alarm to be fully open, if alarm is active, output is 100%
  - If output is between 20 and 80, status is on and no alarm present

Binary outputs

- A binary output may be used in these ways:
- Binary Mode: ON-OFF control or manual
- 3-point mode: One actuator is controlled: Open or Close, preferably use TRIAC products.
- PWM Mode: Pulse width modulation. An actuator is modulated by variable ON – OFF times. For shorter cycle times TRIAC products must be used as the relays life time is limited to approx 100’000 switch cycles.

Binary outputs selection

- Assign output to either loop 1 or loop 2
  - Heating sequence only
  - Cooling sequence only
  - Heating and cooling sequence
- Assign output to dehumidifying function
  - Maximum demand of loop 1 and loop 2, cooling sequence
- Assign output to operation state
  - On while operation state is on
  - On while operation state is on and controller in heating mode
  - On while operation state is on and controller in cooling mode

3-point output

- Use two binary outputs as one floating output
- Set parameter for running time of actuator, to calculate actuator position
- Set minimum output differential to avoid unnecessary switching
- Internal reset algorithm provided to avoid long term positioning errors
- Guaranteed full open / close positions
- Position calculation and feedback option to display and BAS system

On-Off / PWM output

- PWM: Set cycle time > 0 activates PWM mode
- PWM: Cycle time is constant, based on demand from control loop ON vs OFF time is variable. For example cycle time 100s and 80% demand: On time 80s, off time 20s.
- ON-OFF: Set switch on and switch off delay
- This way it is possible to start up or stop a device before another one.
  For example fan and heating device. Add a start up delay to the heater and no startup delay for the fan. Add a switch off delay for the fan and none for the heater.

Alarms

	Input 1	Input 2	Input 3	Input 4
Low limit	ALA1	ALA3	ALA5	ALA7
High limit	ALA2	ALA4	ALA6	ALA8

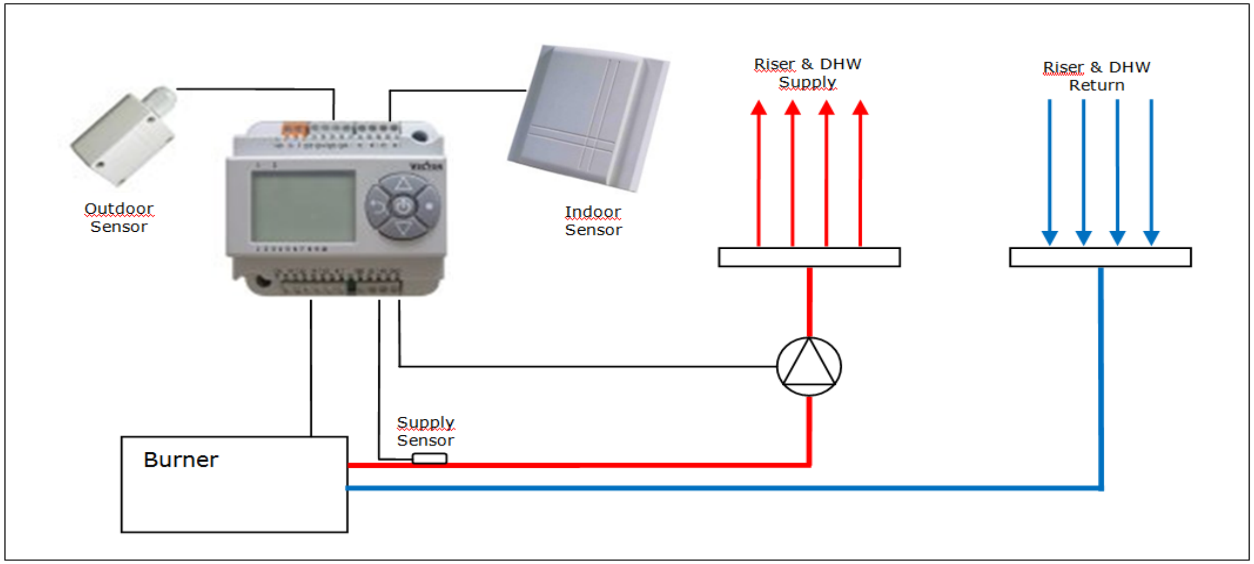
- All inputs feature low limit and high limit alarms
  - Define alarm limit
  - Define hysteresis for alarm to return to inactive
- Alarms show on screen when active and blink when return to normal until acknowledged.
- Acknowledging may be disabled by parameter UP15
- All outputs can be switched on or off during an alarm
- Each alarm can be selected individually on each output
- If an output is set to ON and OFF during the same alarm: OFF prevails.

Schedules

- 8 Schedules are available on the TCI-C22 and TCI-W22 products.
- Each schedule consists of a action time in steps of 15 minutes, a selection of action day (days can be picked individually) and a schedule action.
- Schedule actions:
  - Change operation modes: On, Off, Standby
  - Change control loop setpoint
  - Change position of output. (output must be in manual mode)
- Reset time: Controller will return to off mode after reset time expired, if manually activated during scheduled off mode.

Applications

▲ Boiler control



Outdoor compensation on primary loop

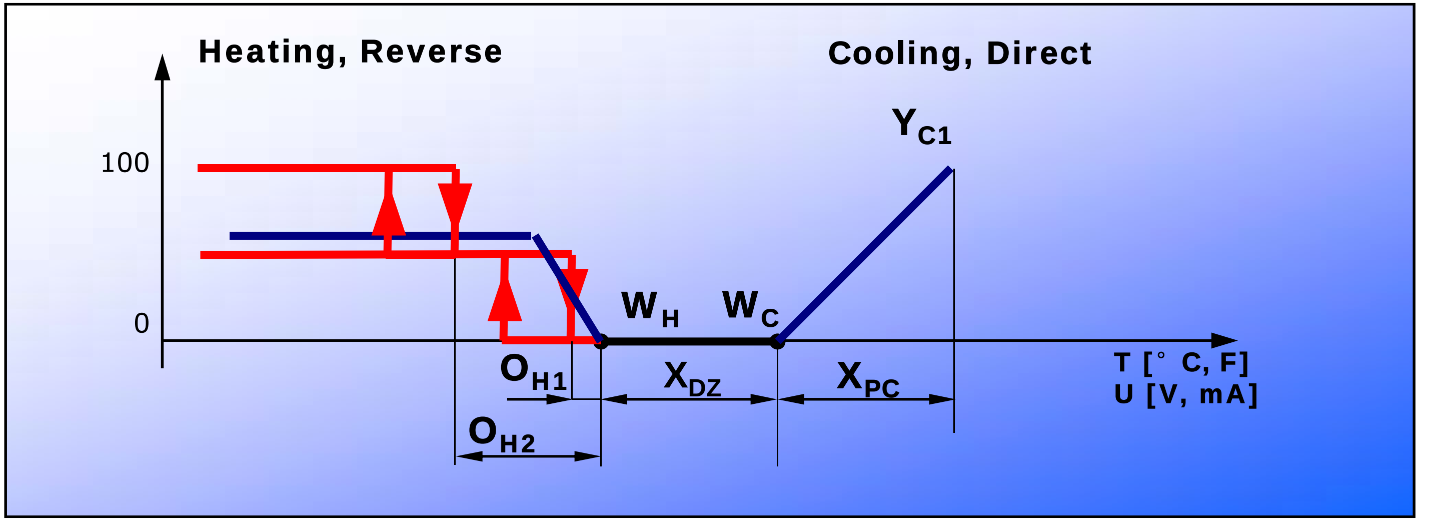
Cascade with secondary loop to control supply water temperature

On delay for burner

Off delay for pump

Applications

▲ VAV, Two Re-Heat stages



Parameters:

AO1		BO1
1A00 = 1 (loop 1)	1A05 = 20% (min cooling)	1D01 = 1 (loop 1)
1A01 = 2 (2-pipe)	1A06 = 80% (max cooling)	1D02 = 0 (heat stage 1)
1A03 = 10% (min heating)		
1A04 = 40% (max heating)	1L17 = 2.0 (Offset stage 1)	2D01 = 1 (loop 1)
Rest use standard parameters		2D02 = 3 (heat stage 2)