SETTING UP A ZONING SYSTEM

with Prolon

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PL-INSTL-SETUPZONE-F-EN

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Setting up a Zoning System with Prolon

The Prolon Control System can be configured for 2 kinds of HVAC zoning system principles, which are commonly known as "VAV" systems and "Changeover Bypass" systems.

The following principles are general descriptions of HVAC zoning applications. Although common, these principles must not be interpreted as absolute guidelines when doing system design. Each HVAC installation is different and unique, and there are endless variations based on these principles.

VAV System Principle

VAV systems (Variable Air Volume) typically have a central A/C unit (rooftop, split system, heatpump, etc.) providing conditioned air to a number of zones through a network of ventilation ducts. Each zone is independent and equipped with a damper that opens or closes to satisfy space temperature demand. These systems generally supply cooling only to the zones at all times when the building is occupied. The target discharge temperature for the cool air supplied by the A/C unit is either fixed or reset by another variable, such as outdoor or return air temperature. With a VAV system, as a zone calls for cooling, its damper opens to let cool air enter the space. It eventually closes as the zone becomes satisfied. If the call is for heating, the damper remains closed since it is designed to strictly provide cooling. In this instance, the VAV Controller sequence is considered to be "Cooling Only". Should heating be required in the space, the zone must be equipped with a terminal duct heater, used to reheat the incoming air into the zone. When such a zone calls for heating, the damper opens to an intermediate position, giving proper air flow to the duct heater so it can reheat the incoming cool air from the central A/C unit and provide warm/hot air to the space. In this instance, the VAV Controller is considered to be "Cooling Only with Reheat". VAV systems are very common in applications where cooling loads are prevalent year round.

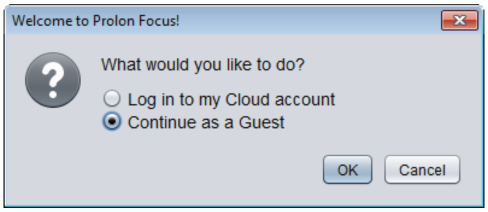
Changeover Bypass System Principle
(also known as "VVT", or Variable Volume and Temperature)

Changeover Bypass systems (or "VVT") are very similar to VAV systems as they too have a central A/C unit providing conditioned air to zones equipped with dampers. They differ however by using A/C units that provide either cooling or heating to the zones. Since the A/C unit changes its supply over from heating to cooling and vice-versa to satisfy various heating and cooling demands, its supply temperature is always variable. Each zone calculates its own demand and factors in a voting weight which will determine how much of an influence it will have on the system (if every zone has the same voting weight, every zone has equal influence). The A/C Unit Controller receives and analyzes these demands, and will then decide to provide heating or cooling based on a user-defined strategy (highest heat/cool call, weighted average, etc.). This is known as a demand-based system. Additionally, the zones have a changeover logic of their own; each Zone Controller "knows" whether the supply air temperature fed is cool or hot, and therefore will only modulate its damper to open if the supply air available matches its own demand. Each zone may also be equipped with a duct heater for additional heating capabilities. "VVT" systems are common in applications where heating and cooling loads change year round.

1 - Creating a New Project in Focus

1.1 - Opening Focus for the First Time

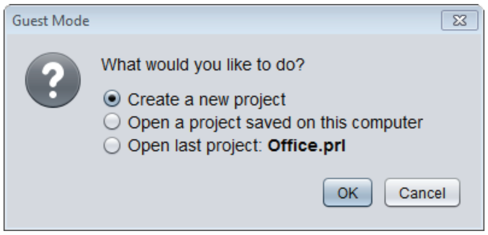
- When you first open the Prolon Focus software, the following window will appear (see image below):
  - ▹ Log in to my Cloud account
  - ▹ Continue as a Guest
- Select "Continue as a Guest". *



**Guest mode will be used for the purposes of this guide. For Cloud account information, please refer to the Prolon Focus User Guide.*

1.2 - Guest Mode

- Upon selecting Guest mode, the following window will appear (see image below):
  - ▹ Create a new project
  - ▹ Open a project saved on this computer
  - ▹ Open last project
- Select "Create a new project".

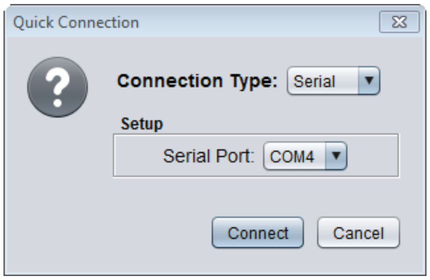


1.3 - Connect to as Controller or Work Offline

- Upon selecting to create a new project, Focus will ask the user how to connect to the system (see image below):
  - ▹ Serial Connection: choose this option to connect to any Prolon Controller using either a USB cable (PL-NC2000 Network Controller only) or an RS485-to-USB adapter (any Prolon Controller)
  - ▹ IP Connection: choose this option to connect to a Network Controller (PL-NC2000) using a static IP address
  - ▹ Modem Connection: choose this option to connect to any Prolon Controller using a dial-up Modem

- ▹ Cloud connection: choose this option to connect to a Network Controller (NC2000) via Cloud Communication (not available in Guest Mode)

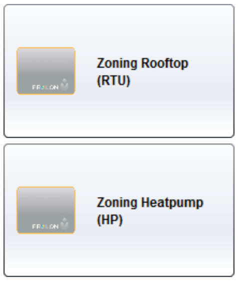
- Press cancel to work offline.



2 - Create Controller Icons in Focus Software

2.1 - Create a Unit Controller in Focus

- Drag-and-drop a Unit Controller icon ("Zoning Rooftop (RTU)" or "Zoning Heatpump (HP)") from the left-hand side menu.

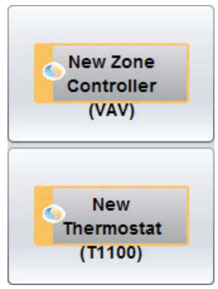


- Enter the controller address, as set with its dip switches, between 1 and 127.
  - ▹ If in "Offline Mode":
    1. Focus will ask you to indicate the hardware version.
    2. Select the appropriate hardware for your job. (This exercise will use the M2000 hardware)
    3. The icon will appear, and will be colored gray.
  - ▹ If you are connected to a controller, the icon will appear onscreen, and will be coloured either green, blue or red, depending on the state of the controller.

2.2 - Create a Zone Controller in Focus

In the Prolon focus software:

- Drag-and-drop a Zone Controller icon (“New Zone Controller (VAV)” or “New Thermostat (T1100)”) from the left hand-side menu into the blue Focus workspace.

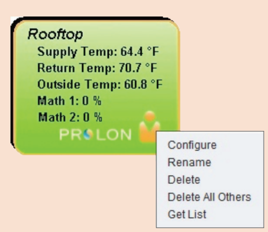


- Enter its address (between 1 and 127)
  - ▹ If in "Offline Mode":
    1. Focus ask you to indicate the hardware version.
    2. Select the appropriate hardware for your job. (This exercise will use the VC2000 hardware.)
    3. The icon will appear, and will ne colored gray.
  - ▹ If you are connected to a controller, the icon will appear onscreen, and will be coloured either green blue or red, depending on the state of the controller.

2.3 - Repeat for Every Zone

- Repeat section 2.2 for every Zone Controller on the network as required.

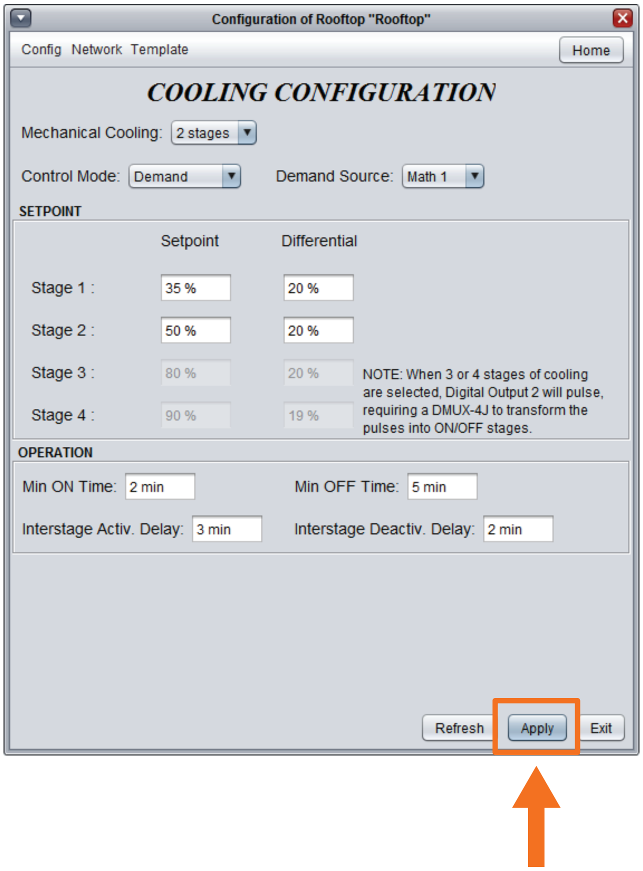
BEST PRACTICES:
If your Zone Controllers have been wired to communicate with the Unit Controller, there is a simpler and much quicker method to create all the zone icons. Simply right-click on the Unit Controller icon, and select “Get List”. The Unit Controller will put a call on its network, all zones which “hear” the call will respond and their respective icons will appear on the Focus screen.



3 - Configuring a Changeover Bypass System *("VVT")*

3.1 - Applying a Configuration Change

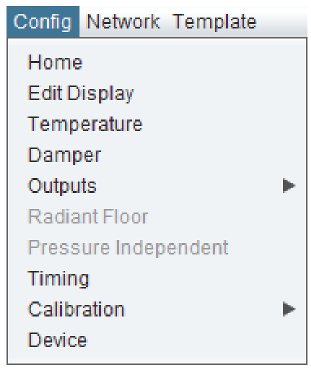
When making changes to a controller, do not forget to press the "Apply" button (located on the bottom right of every configuration menu) to upload the changes to the controller. If the "Apply" button is not pressed, the change will not be uploaded to the controller.



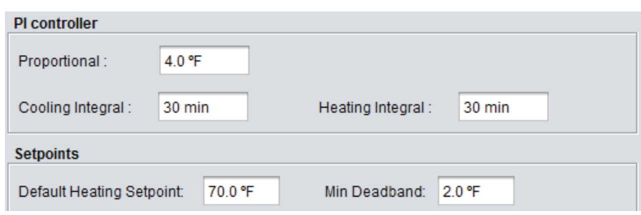
3.2 - Configuring a Zone Demand and Voting Weight *(Zone controller menu)*

3.2.1 - Zone Demand

- Open a Zone Controller by double-clicking on its icon.
- On the top left of the screen, select "Config" and then "Temperature".



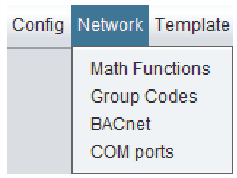
- In the "Temperature" menu, the "Proportional", "Cooling Integral" and "Heating Integral" values will determine how quickly a zone's demand will increase or decrease depending on the space temperature and the cooling and heating setpoints. (See Annex A for details).



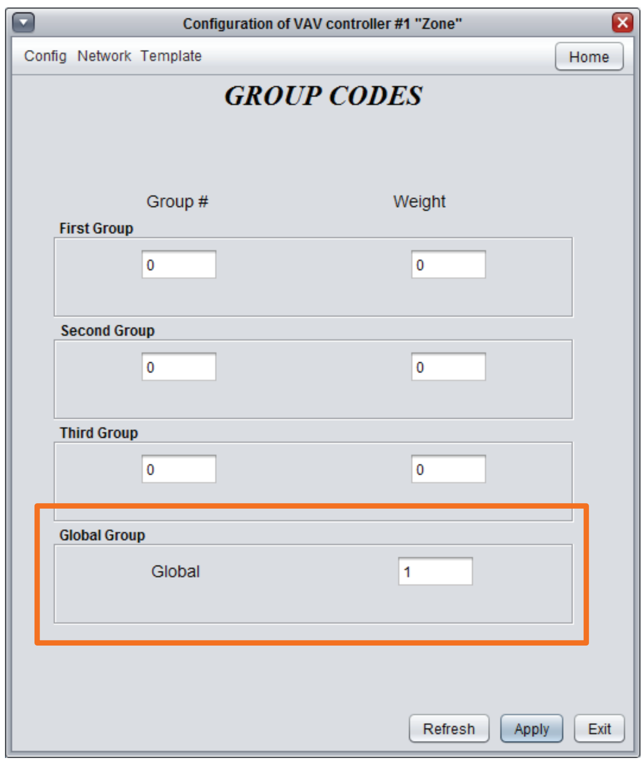
BEST PRACTICES:
It is recommended to set the Cooling Integral and Heating Integral to 30min each. It is not recommended to set the integrals to less than 10 min as this may cause severe zone temperature swings.

3.2.2 - Zone Voting Weight

- On the top left of the screen, select "Network" and then "Group Codes".



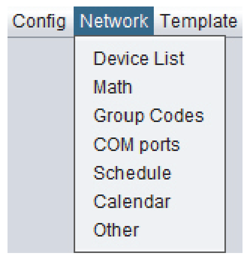
- In the "Group Codes" menu, select the zone's weight in the "Global Group" (defaulted at 1). If the user desires a zone to have a greater influence on the system, increase the weight. If the user desires a zone to NOT have any influence on the system, configure the weight to zero.



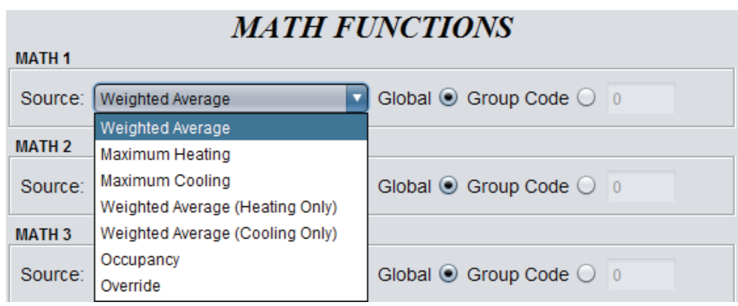
BEST PRACTICES:
On most systems, it is best to leave the individual zone weight at its default (1). Should you need to increase a zone's specific weight, set it to 2 or 3. Above that, the influence from any given zone becomes too great and may create a system imbalance.

3.3 - Configuring a Math Function *(Unit controller Menu)*

- Open a Unit Controller (Zoning Rooftop or Zoning Heatpump Controller) by double-clicking on its icon.
- On the top left of the screen, select "Network" and then "Math".



- Select the Math Functions as follows:
  - ▹ Math 1 ⟶ Weighted Average (Cooling only)*
  - ▹ Math 2 ⟶ Weighted Average (Heating only)**



** Weighted Average (Cooling only): this is calculated by multiplying the demand of each slave with a COOLING DEMAND by its respective weight and adding them together. The result is then divided by the total weight of zones in the system. This provides a math function whose final result is more influenced by the zones with greater weight. (See Annex B)*

*** Weighted Average (Heating only): this is calculated by multiplying the demand of each slave with a HEATING DEMAND by its respective weight and adding them together. The result is then divided by the total weight of zones in the system. This provides a math function whose final result is more influenced by the zones with greater weight. (See Annex B)*

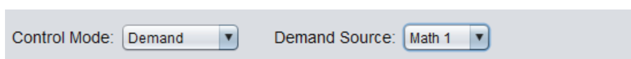
BEST PRACTICES:

- If you are setting up a system with few zones (i.e. 2 or 3 zones), in most cases it may be more appropriate to set the Math 1 to "Maximum Cooling" and Math 2 to "Maximum Heating", so the unit will respond to the zone with the highest cooling or heating demand.
- If you are setting up a system with more than a few zones (i.e. 4 zones or more), it is best to select the "Weighted Average (Cooling Only)" and "Weighted Average (Heating Only)" functions, as seen above.
- Keep the Math function toggle to "Global". It is not recommended to use "Group Code" (used for more advanced and specific applications, not seen in this guide).

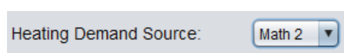
3.4 - Assign Math Functions to Cooling and Heating Outputs
(Unit Controller Menu)

- On the top left of the screen, select "Config" and then "Cooling".

- In the "Cooling" menu, set the "Cooling Demand Source" to "Math 1".



- In the "Heating" menu, set the "Heating Demand Source" to "Math 2".



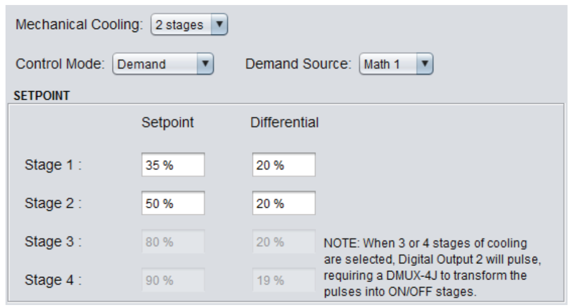
With this configuration, the Cooling in the Unit Controller will be activated based on the values coming from the Math 1 function, which is a weighted average of all cooling demands from all the followers. The Heating in the Unit Controller will be activated based on the values coming from the Math 2 function, which is a weighted average of all heating demands from all the followers. (SEE SECTION 3.2).

3.5 - Configuring the Cooling

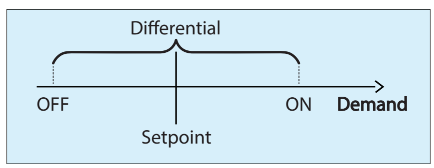
- On the top left of the screen, select "Config" and then "Cooling".

3.5.1 - Unit with Cooling Stages *(On-Off)*

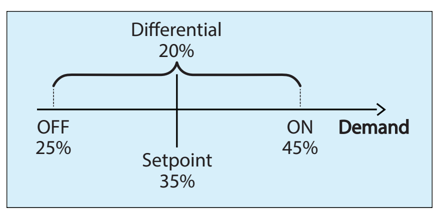
- Set the Control Mode to "Demand".
- Select how many cooling stages in the "Mechanical Cooling" dropdown list (up to 4x stages).



- The setpoint and differential values determine when the cooling stage turns on, and when it turns off. The differential is centered on the setpoint.



- Looking at Stage 1, with a setpoint of 35% and a differential of 20%:



- Stage 1 will be activated once the demand (source: Math 1) reaches the following point:

Stage 1 On = Setpoint + 1/2 (Differential)
Stage 1 On = 35% + 1/2 (20%) = 45%

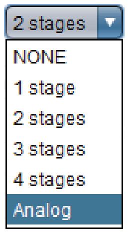
- When Stage 1 is activated, the unit will supply cool air to the zones.
- All VAV zones with a cooling demand will open their dampers. All zones with a heating demand will close their dampers to their minimal positions (unless duct heater reheat has been enabled).
- As the zones receive cool air, their individual cooling demands will decrease, thus directly affecting Math 1. As a result, Math 1 will decrease.
- Stage 1 will be deactivated once the demand (source: Math 1) reaches the following point:

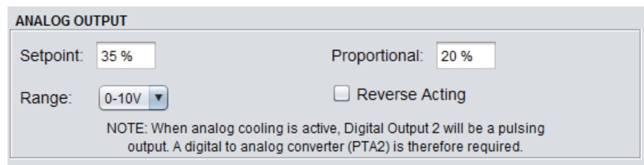
Stage 1 Off = Setpoint - 1/2 (Differential)
Stage 1 Off = 35% - 1/2 (20%) = 25%

- Configure additional cooling stages as needed using the same guidelines.

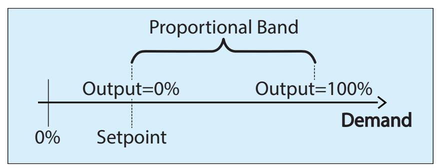
3.5.2 - Unit with Analog Cooling *(Modulating)*

- Select "Analog" in the "Mechanical Cooling" dropdown list.

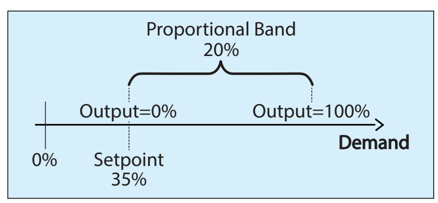




- The setpoint value indicates when the cooling is activated, and the proportional value is the 0-100% output range.



- Looking at the modulating cooling, with a setpoint of 35% and a proportional band of 20%.



- The Analog Output will begin to increase its voltage when the demand (source: Math 1) reaches 35%. As the cooling demand increases, the voltage output will increase proportionally. Once the cooling demand reaches 55% (setpoint + proportional band), the output will be 100%.

- Look at the following example for a 50% cooling demand:

$$Setpoint = 35\% \qquad Demand = 50\%$$

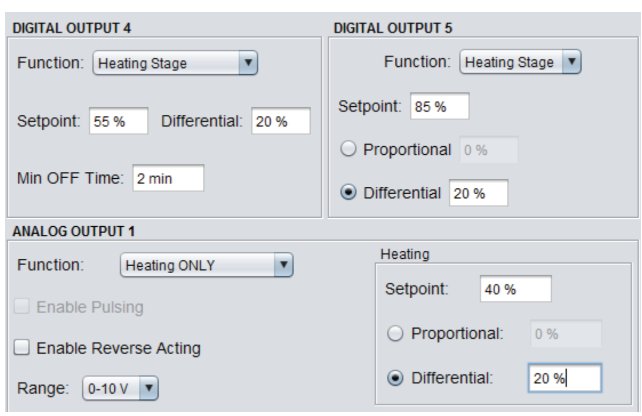
$$Voltage\ output = \frac{Demand - Setpoint}{Proportional\ Band} \times 10Vdc = \frac{50 - 35}{20} \times 10Vdc = 7.5Vdc$$

3.6 - Configuring the Heating

- On the top left of the screen, select "Config" and then "Heating".

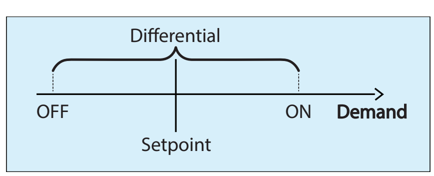
3.6.1 - Unit with Heating Stages *(On-Off)*

- Choose which available outputs will be used for the heating stages (Digital Output 4, Digital Output 5 and/or Analog Output 1). Each output has a dropdown menu. If a specific output is not being used, set it to "OFF" in the output's respective dropdown list.

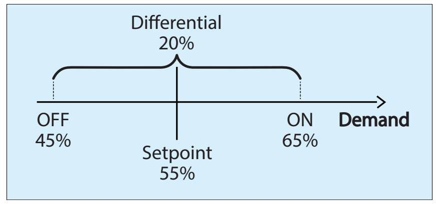


- If using Analog Output 1 to control an on-off heating stage, be sure to select "Differential" ("Proportional" is used for a modulating output, details in Section 3.5.2)

- The setpoint and differential values determine when the heating stage turns on, and when it turns off. The differential is centered on the setpoint.



- Looking at Stage 1, with a setpoint of 55% and a differential of 20%:



- Stage 1 will be activated once the demand (source: Math 2) reaches the following point:

Stage 1 On = Setpoint + 1/2 (Differential)
Stage 1 On = 55% + 1/2 (20%) = 65%

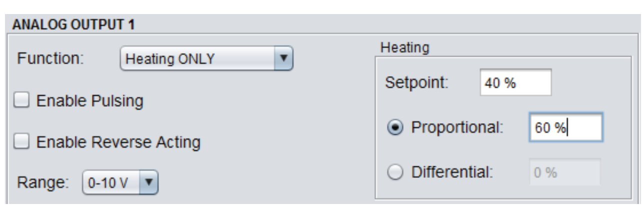
- When Stage 1 is activated, the unit will supply warm/hot air to the zones.
- All VAV zones with a heating demand will open their dampers. All zones with a cooling demand will close their dampers to their minimal positions.
- As the zones receive warm/hot air, their individual heating demands will decrease, thus directly affecting Math 2. As a result, Math 2 will decrease.
- Stage 1 will be deactivated once the demand (source: Math 2) reaches the following point:

Stage 1 Off = Setpoint - 1/2 (Differential)
Stage 1 Off = 55% - 1/2 (20%) = 45%

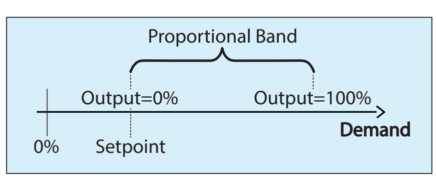
- Configure additional heating stages as needed using the same guidelines.

3.6.2 - Unit with Analog Heating *(Modulating)*

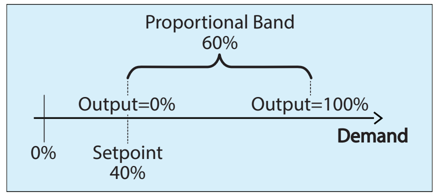
- Disable Digital Output 4 and Digital Output 5 by setting them to "OFF" in their respective dropdown list.
- Select "Heating" in Analog Output 1.
- Select "Proportional".



- The setpoint value indicates when the heating is activated, and the proportional value is the 0-100% output range.



- Looking at the modulating heat, with a setpoint of 40% and a proportional band of 60%.



- The Analog Output 1 will begin to increase its voltage when the demand (source: Math 2) reaches 40%. As the heating demand increases, the voltage output will increase proportionally. Once the demand reaches 100%, the output will be 100%.

- Look at the following example for a 80% heating demand:

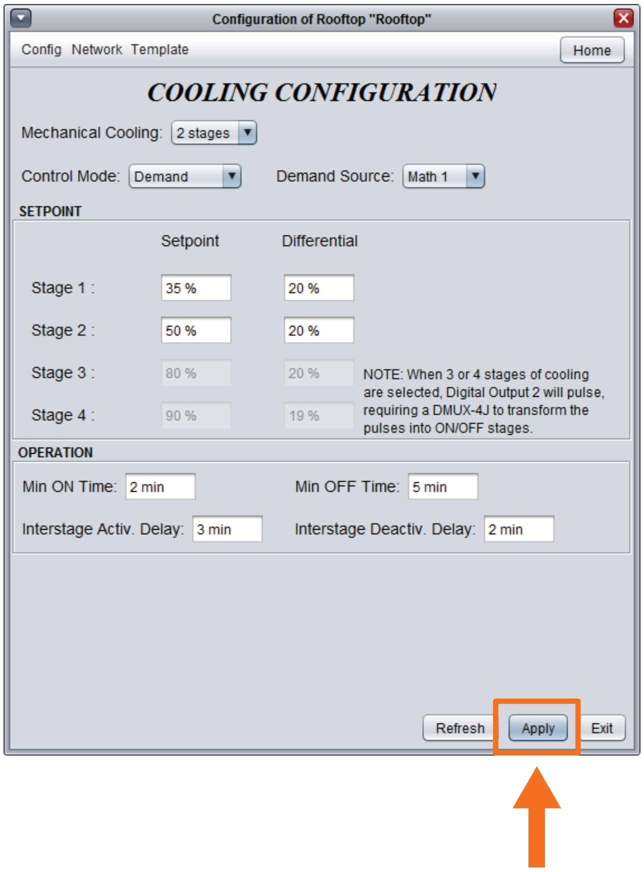
$$\textit{Setpoint} = 40\% \qquad \textit{Demand} = 80\%$$

$$\textit{Voltage output} = \frac{\textit{Demand - Setpoint}}{\textit{Proportional Band}} \times 10\textit{Vdc} = \frac{80 - 40}{60} \times 10\textit{Vdc} = 6.67\ \textit{Vdc}$$

4 - Configuring a VAV System *(Variable Air Volume)*

4.1 - Applying a Configuration Change

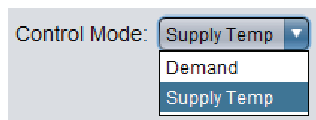
When making changes to a controller, do not forget to press the « Apply » button (located on the bottom right of every configuration page) to upload the changes to the controller. If the "Apply" button is not pressed, the change will not be uploaded to the controller.



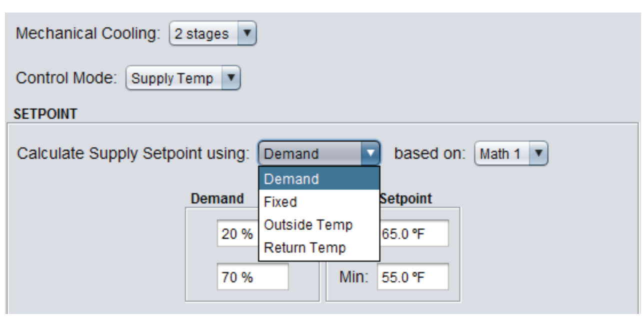
4.2 - Configuring the Cooling Stages

- On the top left of the screen, select "Config" and then "Cooling".

- Set the Control Mode to "Supply Temp".

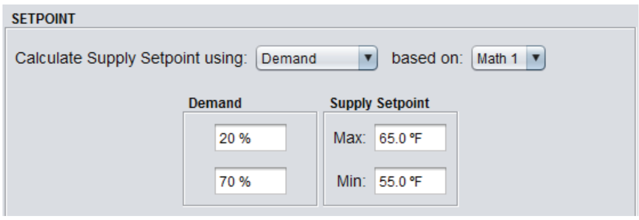


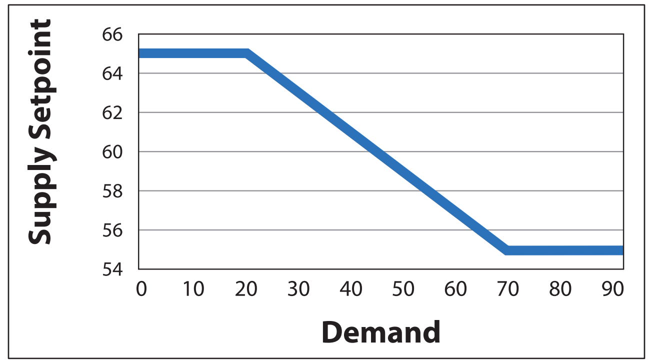
- Choose how to calculate the Supply Temperature according to the following options:
  - ▹ Demand (default)
  - ▹ Fixed
  - ▹ Outside Temp (i.e. outside temperature reset)
  - ▹ Return Temp (i.e. return temperature reset)



4.2.1 - Calculate Supply Setpoint Using "Demand"

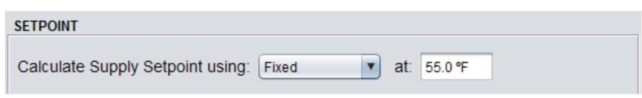
By setting "Calculate Supply Setpoint using Demand", the target discharge temperature in the supply will be reset based on the demand coming from a Math function (in this case, source Math 1). See SECTION 3.2 for more details on the Math functions.





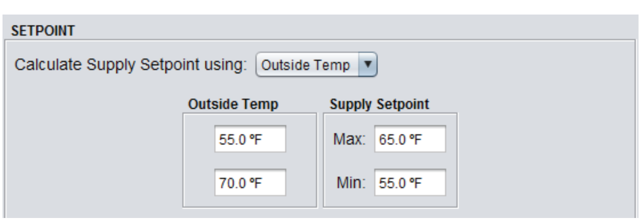
4.2.2 - Calculate Supply Setpoint Using "Fixed"

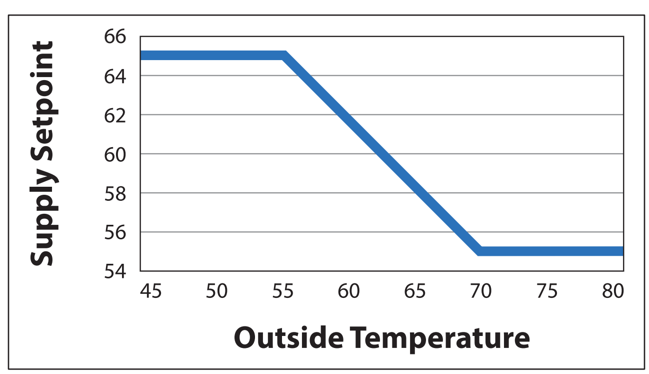
By setting "Calculate Supply Setpoint using Fixed", the target discharge temperature in the supply is fixed, and will not vary.



4.2.3 - Calculate Supply Setpoint Using "Outside Temperature"

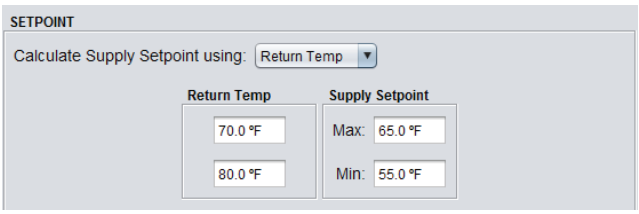
By setting "Calculate Supply Setpoint using Outside Temp", the target discharge temperature in the supply will be reset based on the outside temperature.

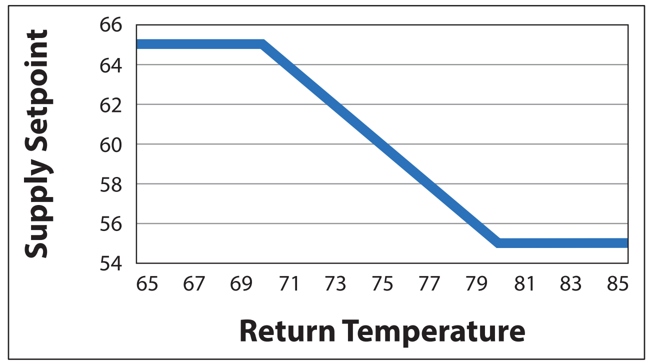




4.2.4 - Calculate Supply Setpoint Using "Return Temperature"

By setting "Calculate Supply Setpoint using Return Temp", the target discharge temperature in the supply will be reset based on the return temperature.



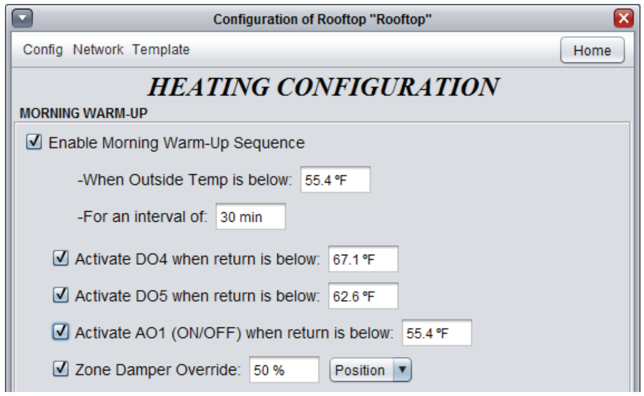


4.3 - Configuring the Morning Warm-Up

When the cooling mode is set to "Supply Temp", the heating configuration menu will automatically update to display the morning warmup setup.

- On the top left of the screen, select "Config" and then "Heating".

- Click the "Enable Morning Warm-Up Sequence" checkbox. This sequence will be enabled upon a transition from "Unoccupied" to "Occupied".



- Enter the Outside Temperature below which the "Morning Warm-Up Sequence" is enabled (Default 55.4ºF).
- Enter the interval of time for which the "Morning Warm-Up Sequence" is enabled (Default 30min).
- Click the appropriate checkbox to activate Digital Output 4, Digital Output 5 and Analog Output 1 based on the mechanical equipment's setup. The outputs will activate their respective heating stages if the return air temperature is below their indicated value.
- In this example:
  - ▹ Digital Output 4 will activate its heating stage if the return temperature is below 67.1ºF;
  - ▹ Digital Output 5 will activate its heating stage if the return temperature is below 62.6ºF;
  - ▹ Analog Output 1* will activate its heating stage if the return temperature is below 55.4.
  - ▹ These values can be changed to suit the specific requirements of the project.

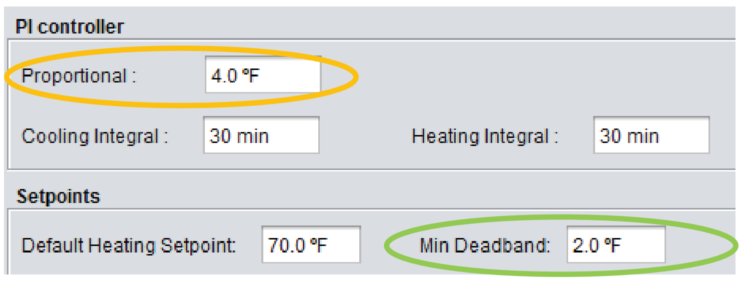
  ** Analog Output 1 will have to be ON-OFF , i.e. 0VDC (OFF) or 10VDC (ON). If a digital contact is required, use a 10VDC relay.*

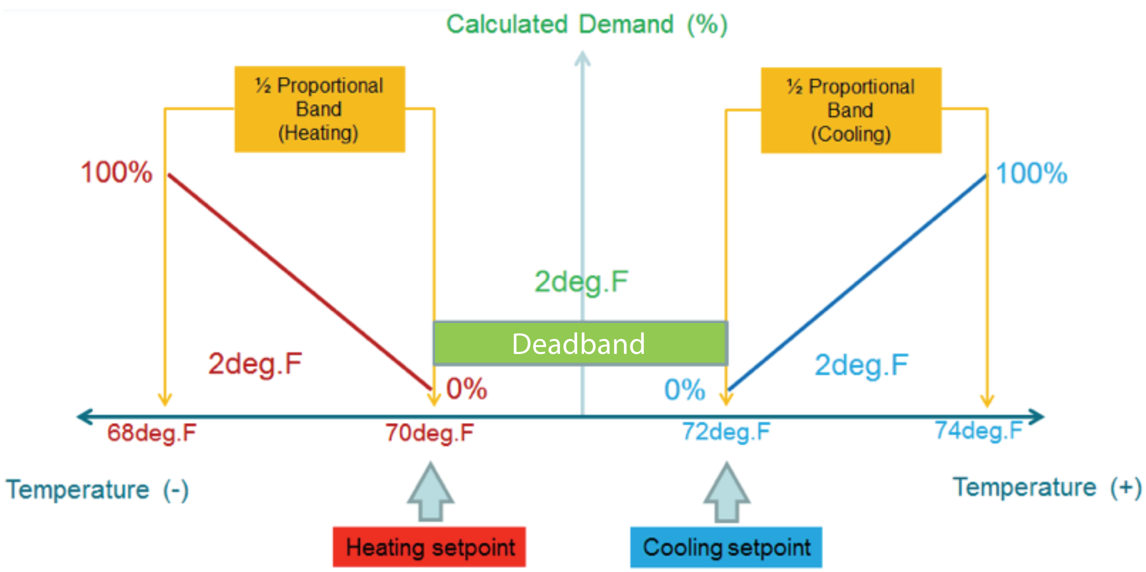
- Click the "Zone Damper Override" checkbox to force all zone dampers to a specific position when the Morning Warm-Up Sequence is **active**.

Annex A *(Proportional + Integral Control)*

This annex explains in detail how a zone's demand is calculated. A zone's demand is calculated by **adding the integral component to the proportional component**.

Proportional Component

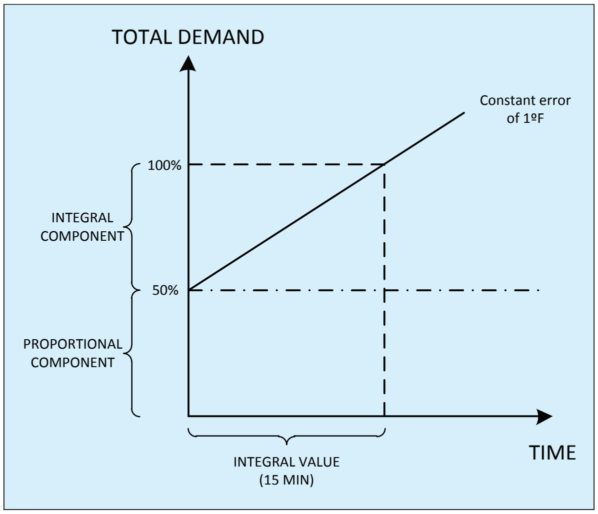




KEY CONCEPTS

- **Heating Setpoint**: temperature below which a heating demand will be created. In the graphic above, heating setpoint = 70ºF, and is usually set by the wall sensor setpoint adjustment dial or touchpad.
- **Cooling Setpoint**: temperature above which a cooling demand will be created. In the graphic above, cooling setpoint = 72ºF and is usually set by the wall sensor setpoint adjustment dial or touchpad.
- **Deadband**: temperature band between the heating and cooling setpoints, at which the space has a 0% demand, and the zone is considered to be satisfied. In the graphic above, deadband = 2.0ºF and can be configured in the "Min Deadband" box.
- **Proportional Band**: Temperature band divided into 2 halves, with one half placed below the Heating Setpoint, and the other half placed above the Cooling Setpoint. Each half band represents the temperature deviation from setpoint needed to create a 100% demand.

Integral Component



KEY CONCEPTS

- The Proportional Component is not enough to satisfy the zone demand
- As long as there is a Proportional Component, the Integral Component will increase **with time**.
- Cooling integral: Amount of time for the Integral Component of the demand to equalize the Proportional Component for a cooling demand.
- Heating integral: Amount of time for the Integral Component of the demand to equalize the Proportional Component for a heating demand.

Scenario

Consider the following situation:

- Space Temperature = 69ºF
- Heating Setpoint = 70ºF // Cooling Setpoint = 72ºF
- Proportional Band = 4ºF
- Heating Integral = 30min // Cooling Integral = 30min
- The space temperature **has remained constant for 15 minutes**.

Here is how we calculate the zone demand:

$$\textit{Zone Demand} = \textit{Proportional Component} + \textit{Integral Component}$$

Proportional Component

$$\text{Proportional Component} = \frac{\text{Heating Setpoint} - \text{Space Temperture}}{\text{1/2 Proportional Band}} \times 100\ \%$$

$$\text{Proportional Component} = \frac{70\ °F - 69\ °F}{1/2\ (4\ °F)} \times 100\ \%$$

$$\text{Proportional Component} = \frac{1\ °F}{2\ °F} \times 100\ \% = 0.5 \times 100\ \%$$

$$\text{Proportional Component} = 50\ \%$$

Integral Component

$$\text{Integral Component} = \frac{\text{Time Elapsed}}{\text{Integral Time}} \times \text{Proportional Component}$$

$$\text{Integral Component} = \frac{15\ \text{minutes}}{30\ \text{minutes}} \times 50\ \%$$

$$\text{Integral Component} = 0.5 \times 50\ \%$$

$$\text{Integral Component} = 25\ \%$$

Zone Demand

$$\text{Zone Demand} = \text{Proportional Component} + \text{Integral Component}$$

$$\text{Zone Demand} = 50\ \% + 25\ \%$$

$$\text{Zone Demand} = 75\ \%$$

After 15 minutes have elapsed, and the space temperature having remained at 69ºF, the zone will have a 75% heating demand.

Annex B *(Math Function Examples)*

In this annex, a scenario is presented. Using different configurations previously explained in this guide, we will see the different Math Function results, depending on which strategy is chosen.

Scenario

A rooftop unit is controlled with a PL-M2000-RTU controller, and the system has 10x VAV zones.

Each zone creates its own individual demand, either heating or cooling demand, from 0 to 100%. Each zone also has its own voting weight (for more details, see SECTION 3.1 CONFIGURE A ZONE DEMAND AND VOTING WEIGHT)

Note: In Prolon Focus, the heating demands are POSITIVE values, and cooling demands are NEGATIVE values.

Each zone of the 10 VAV zones has the following heating or cooling demands:

Zone #1: 100% Heating demand, voting weight of 1
Zone #2: 100% Heating demand, voting weight of 1
Zone #3: 75% Heating demand, voting weight of 2
Zone #4: 10% Heating demand, voting weight of 1

Zone #5: 0% demand, voting weight of 1

Zone #6: 25% cooling demand, voting weight of 2
Zone #7: 35% Cooling demand, voting weight of 1
Zone #8: 45% Cooling demand, voting weight of 1
Zone #9: 100% Cooling demand, voting weight of 1
Zone #10: 100% Cooling demand, voting weight of 2

In the Unit Controller:
- The Cooling action will be driven by Math 1
- The Heating action will be driven by Math 2

(For more details, see SECTION 3.2 CONFIGURE A MATH FUNCTION.)

THE FOLLOWING IS HOW THE MATH FUNCTIONS ARE CALCULATED:

Configuration 1: Using Weighted Average Functions
(Cooling/Heating only)

- Select Math 1 as "Weighted Average (Cooling only)"
- Select Math 2 as "Weighted Average (Heating only)"

$$\text{Math 1} = \frac{(-25\times2)+(-35\times1)+(-45\times1)+(-100\times1)+(-100\times2)}{1+1+2+1+1+2+1+1+1+2} = -33.1\%$$

$$\text{Math 2} = \frac{(100\times1)+(100\times1)+(75\times2)+(10\times1)}{1+1+2+1+1+2+1+1+1+2} = 27.7\%$$

Configuration 2: Using Maximum Cooling/Heating Functions

- Select Math 1 as "Maximum Cooling"
- Select Math 2 as "Maximum Heating"

Math 1= Maximum (-25;-35;-45;-100;-100)= -100%

Math 2= Maximum (100;100;75;10)= 100%

Configuration 3: Using Weighted Average Functions

- Select Math1 as "Weighted Average"

$$\text{Math 1} = \frac{(100\times1)+(100\times1)+(75\times2)+(10\times1)+(0\times1)+(-25\times2)+(-35\times1)+(-45\times1)+(-100\times1)+(-100\times2)}{1+1+2+1+1+2+1+1+1+2} = -5.4\%$$

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