TAS Systems Controller Guide

V 1.1

Contents

1. Standard Controller Basics

This subsection will deal with teaching the basics of creating standard controllers. It will discuss: what is a standard controller, how to create a standard controller, how to place the sensor and what the signal means to each component. While these are the basics of a controller, it is important to get them right as an incorrect sensor placement can lead to a component not operating when needed.

1.1 What is a Standard Controller?

In TAS Systems, a controller is a device that produces a signal which the component will use to change its behaviour. This means that in effect the controller is controlling the component, hence the name. Unlike the other types of controllers, mentioned in Section 4, the Standard controller produces its signal based on readings from any attached sensor(s). A simple example of a Standard controller setup can be seen in Figure 1.

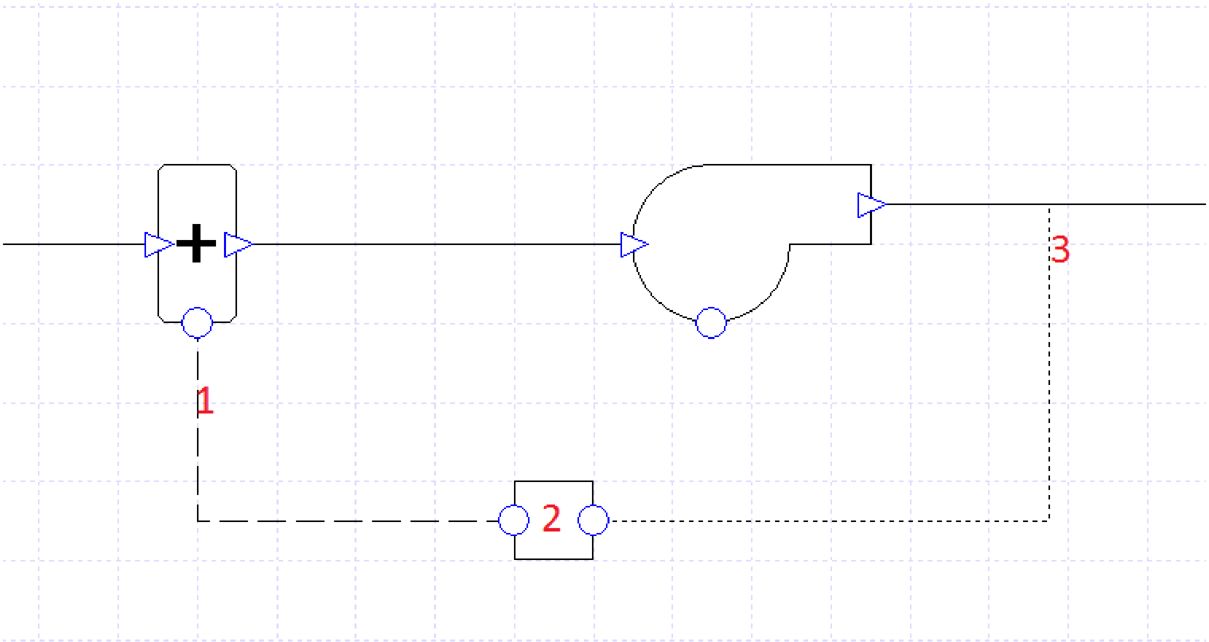

Figure 1: The Basic setup of a controller. Label 1 indicates the controller's connection to the component, label 2 indicates the controller while label 3 indicates the sensor

In Figure 1, the sensor, at label 3, will take a reading from the duct directly after the fan. This signal will then be passed to the controller, at label 2, which converts this reading into a signal. This signal is then passed from the controller to the component, where the component will act according to this signal. With most Standard controllers, the signal will be a value between zero and one. However there is a type of Standard controller, the “Setpoint Passthrough”, that doesn’t operate in this manner. Please see Section 2.1 for more information on the “Setpoint Passthrough” Standard controller.

The different types of Standard controller, along with the different variables the sensor can read and ways to generate the signal (all discussed in Section 2), make the standard controller a very powerful tool in TAS Systems. Knowing how to correctly set up and use a standard controller is vital when setting up systems, especially complex ones, as one small mistake can cause issues with how your system works.

1.2 How to Create / Connect a Controller to a Component?

To create a Standard controller in TAS Systems requires the use of a component that can be used in conjunction with a controller. At the bottom of these components the user will see a circular port which will have a red halo around it once the cursor is placed over it, like in Figure 2.

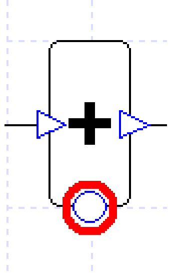

Figure 2: The halo around the circular port.

Once the user clicks and drags away from this circular port, a controller will be created. This controller will, by default, be connected to the component but the user can delete this connection if they wish by clicking on the connection and pressing the delete key on their keyboard (or by choosing delete from the right click contextual menu). Upon deleting the connection the user will need to link the controller back up to another component or delete the controller before they are able to simulate their system. To link a controller back up to a component, the user should click and drag from one of the circular ports on the controller until the newly created connection reaches the circular port at the component, or vice versa.

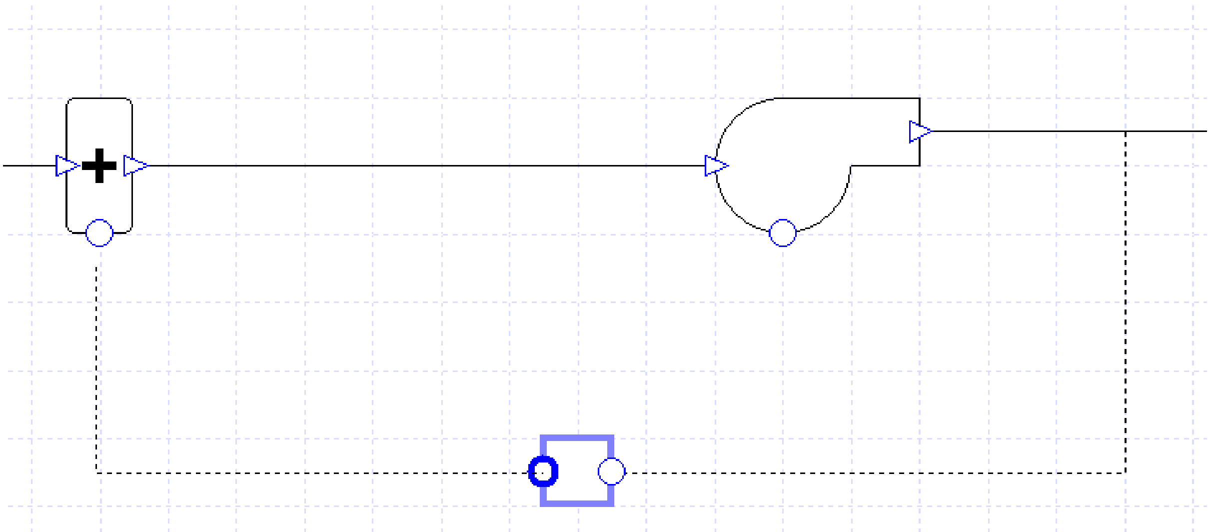

Figure 3: To reconnect the connection between a controller and a component the user should click and drag from one of the two circular ports on the controller and place the connection over the circular port on the component.

Please note that the controller can be attached to multiple components at once, allowing for them to be controlled in the same manner. To do this, the user will have to create connections from the controllers to the components, in the same manner as above. However it should be noted that multiple components should not have more than one controller attached to it (unless the controllers are operating on different day-types, please see Section 2.6 for more on setting which day-types a controller operates on).

1.3 Sensor Placement Within the System

Sensor placement is an important matter in TAS Systems, as the reading from the sensor will be used by the Standard controller to produce a signal. The sensor can only be placed in the following locations:

- On the duct between two components – This means that the sensor takes the reading from the air passing through the duct. To place a sensor here, click and drag from a circular port on a controller to create the sensor and then place the sensor over the appropriate duct.
- Onto a Zone component – This means that the sensor takes the reading from the selected zone. To place a sensor here, click and drag from a circular port on a controller to create a sensor and then place the sensor on the +/- symbol at the bottom of the component. This will be highlighted in red, like in Figure 4.

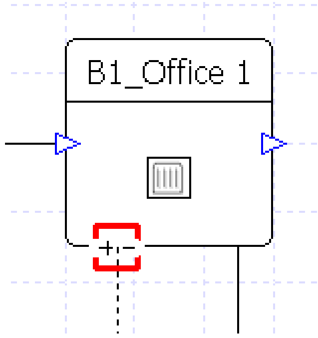

Figure 4: A sensor being attached onto a zone component. The red square surrounding the +/- symbol indicates that the sensor is over the component and will be placed there if the user depresses the mouse.

- Onto a plant room collection – This means that the sensor takes the reading from the attached plant room collection. To place a sensor here requires the same method as the Zone component, but placing the sensor on the +/- symbol of the collection.

It should be noted that the user can link multiple sensors from around their system back to a controller; in fact for one type of Standard controller it is necessary to have two sensors. Even when more sensors are attached to the controller than needed, the user can choose which ones are used by the Standard controller by using the Sensor field within the properties dialog of the controller. More about this Sensor field and the different types of Standard controllers can be found in Section 2.1.

1.4 The Signal's Effect on the Controller

After the controller has passed on the signal to the component, the component will act according to the signal. How the component acts upon receiving the signal depends on the component. As a general rule of thumb, the following is a rough guide on how the components will act:

- **Load components** – Load components are components which have a duty field. With these components, the signal received by the component dictates the proportion of the component's duty it will use to meet the demand. As it is a proportion, a signal of zero will mean the component will not operate while a signal of one means that the component will operate using its full duty.
- **Fan and Pump Components –** For the fan and pump components, a controller controls how much the component will increase the pressure of the medium flowing through it. The signal received by the component dictates the proportion of the maximum pressure increase the component will increase the pressure to. Please note that this maximum pressure increase is not the value entered in the component's Pressure field. Instead the software will work the maximum pressure increase out by taking into account the Pressure field, along with the design flow rates and design pressure drops of components around the system. Also, as pressure and flow rate are linked, controlling the pressure with a controller will also mean that the flow rate will vary. How the signal affects the flow rate is shown using the equation below.

$$\boldsymbol{Flow\ Rate\ at\ signal = Design\ Flow\ Rate * \sqrt{signal}}$$

For the fan component, if the user wishes to set a minimum air flow rate, they could use the Minimum Flow Rate field of the fan. To ensure that this minimum flow rate is met, TAS works out the signal the component requires to meet this flow rate and then sets it as the minimum signal of all attached controllers, ensuring the flow rate doesn't drop below this level.

- **Damper and Valve Components –** For the damper and valve components, the controller controls the capacity of the component, which will impact the flow rate and pressure of the system. The signal the component receives dictates the proportion of the maximum capacity that the component will reduce to. The maximum capacity is set in this case by either the Design Flow Rate field or the Capacity field of the component. As the capacity of the damper or valve varies, so will the flow rate and pressure of the system.
  For a damper, if the user wishes to set a minimum flow rate, they could use the Minimum Flow Rate field of this component. To ensure that this minimum flow rate is met, TAS works out the signal the component requires to meet this flow rate and then sets it as the minimum signal of all attached controllers, ensuring the flow rate doesn't drop below this level.
- **Heat Exchangers and Optimisers** – These components are normally used in conjunction with standard controllers of the "Setpoint Passthrough" type, please see Section 2.1 for more. With this option, the controller doesn't produce a signal between zero and one but instead provides the reading the sensor has taken. The component will then work by exchanging heat / mixing air to make the desired air-stream get as near to the reading as possible.

2 The Standard Controller's Properties

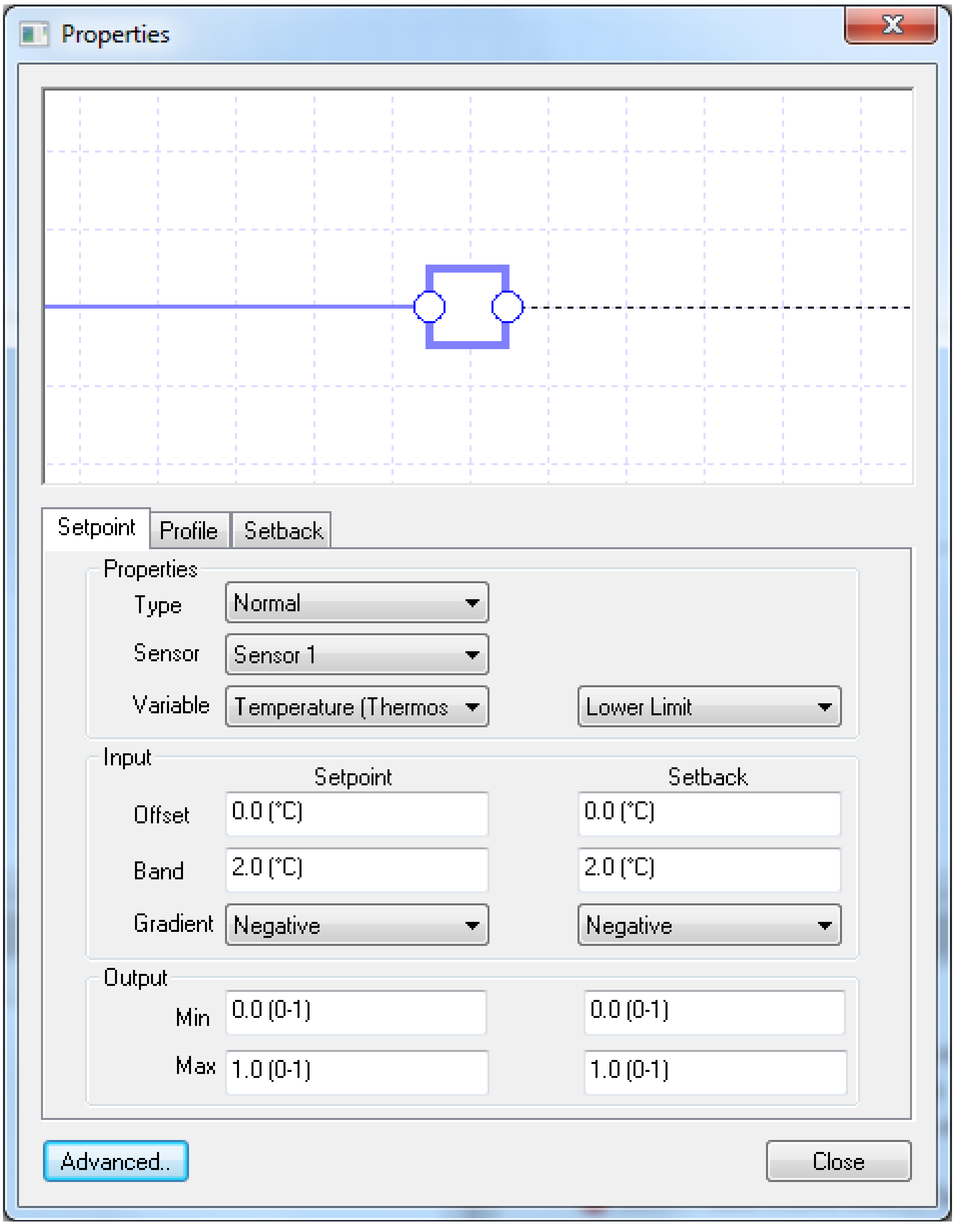

Figure 5: The Properties dialog of the controller, the displayed tab is the Setpoint tab

The Standard controller's properties dialog, with Figure 5 showing the Properties tab of the dialog, allows the user to set up how the controller works. It is from these properties that the user will select what variable the sensor is reading, along with setting up how the signal is produced at the controller. Making sure that your controllers are set up properly is of the utmost importance, as a minor mistake here can significantly change the signal produced at the controller. This could lead to components operating incorrectly and thus producing inaccurate results.

In the following subsections, the guide will talk through the various options available in the properties. It will start off by discussing the properties that affect how the controller manages its sensors and what reading the sensors take. It will then move on to how the controller converts the reading into a signal to be passed on to the component before finally moving onto some of the more advanced options of the Standard controller's properties.

2.1 Setpoint Tab: Properties Box

Within the properties box, in the Setpoint tab, are the three fields which detail how the controller manages the attached sensors. The three fields work in the following way:

- **Type** - The Type field of a standard controller allows the user to choose, from three options, how the controller manages the readings taken from the sensors. The three options work in the following ways:
  - **Normal** – With the Normal option, the sensor reading is taken from the sensor and then used by the controller to produce the signal. Please note if multiple sensors are attached to the controller, the controller will take the reading of the sensor chosen in the Sensor field.
  - **Difference** – With the Difference option, the controller takes readings from two sensors and subtracts one from the other. The difference between the two readings is then used by the controller to produce the signal. Please note that it is required to have at least two sensors attached to the controller to use this option. The Sensor field is used in this instance to decide what sensors are used and the order of subtraction. The minus sign in-between the two drop down menus, as pictured in Figure 6, indicates what sensor's reading will be subtracted from the other.

Figure 6: A screenshot illustrating the way you set the options for the difference controller. Please note the minus sign between the two sensor choices.

  - **Setpoint Passthrough** – A Standard controller of type Setpoint Passthrough can only be used with heat exchangers or optimisers. Any attempt to use this controller type with any other component will produce an error and you will not be able to simulate your system. This type of controller works differently to all other types by not producing a signal between zero and one and also not using a profile to create the signal. Instead, the controller takes the reading from the sensor and uses that as its signal. This signal is then passed onto the component, where it attempts to merge air streams /exchange heat to meet the signal reading. Often it will fall short of mixing to the signal reading, but will reduce the loads on components conditioning the air / fluid.
    It should also be noted that the user will be able to set an offset when using this field, using the Offset field that appears. The offset can be positive or negative and will be applied to the sensor reading to offset the signal. An example using a Standard controller of type Setpoint Passthrough can be seen in Example 5.1.
- **Sensor** - For the Normal and Setpoint Passthrough types, the Sensor field allows the user to decide what sensor reading the controller will use, as these options don't allow for multiple sensors to be used at once. For the Difference type, please read the Difference paragraph of the Type property to see how the Sensor field is used. It should be noted that any sensor attached to the controller and not displayed in the Sensor field will have its sensor readings disregarded.
- **Variable** – The Variable field allows the user to choose what variable all of the sensors attached to the controller are sensing. The available variables are broken up into two categories; Non-Thermostat variables and Thermostat variables. The difference between the two is a Standard controller using a Thermostat variable requires access to other parts of your model to create the signal, see Section 2.3 for more. The user is able to choose from the following variables:
  - **Enthalpy –** The Enthalpy option is a Non-Thermostat variable and is only available for controllers in air-side systems. Upon choosing this option, the sensor will obtain the Enthalpy of the air in the duct or zone.

- **Flow –** The Flow option is a Non-Thermostat variable and is available for controllers in both plant room and air-side systems. When this option is chosen in an air-side system, the sensor will read the flow rate of the air in a duct or zone. When this option is chosen in a plant room system, the sensor will read the fluid flow rate from a duct.
- **Humidity Ratio –** The Humidity Ratio option is a Non-Thermostat variable and is only available for controllers in air-side systems. Upon choosing this option, the sensor will obtain the Humidity Ratio of the air in a duct or zone.
- **Load –** The Load option is a Non-Thermostat variable and is only available for controllers in plant room systems. Upon choosing this option, the sensor will read the load (which in the collection's result section is stated as "demand") from the attached collection. Please note that if you attach the sensor to a duct, the load value read by the sensor will be zero as the duct does not have a load. This will mean that your component will not operate.
- **Pollutant –** The Pollutant option is a Non-Thermostat variable and is only available for controllers in air-side systems. Upon choosing this option, the sensor will obtain the pollutant reading of the air from either a duct or a zone.
- **Pressure –** The Pressure option is a Non-Thermostat variable and is available for controllers in both plant room and air-side systems. Upon choosing this option for an air-side system, the sensor will read the air pressure from the attached duct or zone. When used in a plant room system, the sensor will read the pressure of the fluid in the duct or collection.
- **Relative Humidity –** The Relative Humidity option is a Non-Thermostat variable and is only available for controllers in air-side systems. Upon choosing this option, the sensor will read the relative humidity of the air in a duct or zone.
- **Relative Humidity (Humidistat) -** The Relative Humidity (Humidistat) option is a Thermostat variable and is only available for controllers in air-side systems. When using this option, the sensor will read the relative humidity of the air in the zone. Please note that when using this option you cannot attach the sensor to a duct, as it will produce an error, unless it is the duct immediately after the zone. This error occurs because the controller uses the zone's humidistat, set in the zone's internal condition, to produce the signal. To help TAS identify which zone's humidistat it should be using during this process, the sensor must be attached to the zone or to the duct immediately after the zone. There is more information about how the humidistat limits are used to produce the signal in Section 2.3.
- **Temperature –** The Temperature option is a Non-Thermostat variable and is available for controllers in both plant room and air-side systems. When used in an air-side system, the sensor will read the dry bulb temperature of the air in a duct or zone. When used in a plant room system, the sensor will read the temperature of the fluid from a duct or a collection.
- **Temperature (Thermostat) –** The Temperature (Thermostat) option is a Thermostat variable and is only available for controllers in air-side systems. When using this option, the sensor will read the dry bulb temperature of the air in the zone. Please note that when using this option you cannot attach the sensor to a duct, as it will produce an error, unless it is the duct immediately after the zone. This error occurs because the controller uses the zone's thermostat, set in the zone's internal condition, to produce the signal. To help TAS identify which zone's thermostat it should be using during this process, the sensor must be attached to the zone or to the duct immediately after the zone. There is more information about how the thermostat limits are used to produce the signal in Section 2.3.

- **Wetbulb –** The Wetbulb option is a Non-Thermostat variable and is only available for controllers in air-side systems. Upon choosing this option, the sensor will read the wet bulb temperature of the air in the duct or zone.
- **Min Fresh Air –** The Min Fresh Air option is a Thermostat variable and is only available for controllers in air-side systems. Upon choosing this option, the sensor will read the flow rate of air through the zone. Please note that when using this option you cannot attach the sensor to a duct, as it will produce an error, unless it is the duct immediately after the zone. This error occurs because the controller uses the zone component's Fresh Air Rate field to produce the signal. To help TAS identify which zone's Fresh Air Rate field it should be using during this process, the sensor must be attached to the zone or the duct immediately after the zone. Please note that unlike other Thermostat variables, you do not get to choose a Thermostat limit with this option, as discussed in Section 2.3.

2.2 The Fields Relating to Creating the Signal (Non – Thermostat Standard Controllers)

Once the controller has managed its sensor readings, it must then convert the produced value into a signal for the component. In TAS Systems, the user will need to detail how this conversion process will work by creating a profile the controller can refer to when creating the signal. As this profile will be based on the variable the sensor has read, the user should note that the options for creating this profile will depend on if the user chose a Thermostat variable or a Non-Thermostat variable in the Variable field of the controller's properties. In this sub-section, the guide will explain the process for Non-Thermostat variables. The next sub-section will describe how the signal is created for Thermostat Variables. Controllers that use a Non-Thermostat variable are called Non-Thermostat Standard controllers, while controllers that use a Thermostat variable are called Thermostat Standard controllers.

With Non-Thermostat Standard controllers, the user can create the profile by inputting the data into the fields contained within the Input box or by going straight to the Profile tab and creating the profile there. If the user chooses to use the fields in the Input box, a simple profile will be created based on the variable the sensor is reading. This simple profile will only change once from the maximum possible signal (1 by default) to the minimum possible signal (0 by default), or vice versa, over a set band where it varies linearly. The three fields which help to create this profile do so in the following way:

- **Band –** The Band field of the controller allows the user to enter a proportional band into the controller. This proportional band details the period (in the units of the variable the sensor is reading) that the profile takes to go from the maximum signal of 1 to the minimum signal of 0, or vice versa. Please note that this band between the two values will be linear.
- **Gradient –** The Gradient field allows the user to decide, in their simple profile, whether the proportional band in their profile has a positive or negative linear gradient. If the user chooses the positive option, the profile will start off at the minimum signal of 0 before increasing throughout the proportional band to the maximum signal of 1. Likewise if the user chooses the negative option, the profile will start off at the maximum signal of 1 before decreasing throughout the proportional band to the minimum signal of 0.
- **Value –** The meaning of the Value field will depend on the user's choice in the Gradient field. If the user chooses the positive option in the Gradient field, the Value field requires the user to enter a value such that if the controller has a reading bigger than or equal to this value, it will return a signal of 1. Similarly if the user chooses the negative option in the Gradient field, the Value field requires the user to enter a value such that if the controller has a reading smaller than or equal to this value, the controller will produce a signal of 1.

Before giving an example of using these input fields, it should be noted that the profile created by these inputs will be visible in the Profile tab. It is strongly recommended that the user checks this profile to make sure that they have set the profile up correctly.

We will now work through an example of how this profile is set up in practice using these fields. Let's say that we have a cooling coil which we want to start cooling the air passing through it when a zone's temperature is at 23 °C. We also want the coil to cool using its full duty when the zone is at a temperature of 24 °C and above. In this example, we would create a Standard controller from the cooling coil with the sensor attached to the zone. The Standard controller would be of Normal type while the variable the sensor is reading would be temperature. In the Input box, the user would enter the following details to create the profile:

- **Band –** 1 °C
- **Gradient –** Positive
- **Value –** 24 °C

This will produce the required control strategy, which can be seen by looking at the profile on the Profile tab.

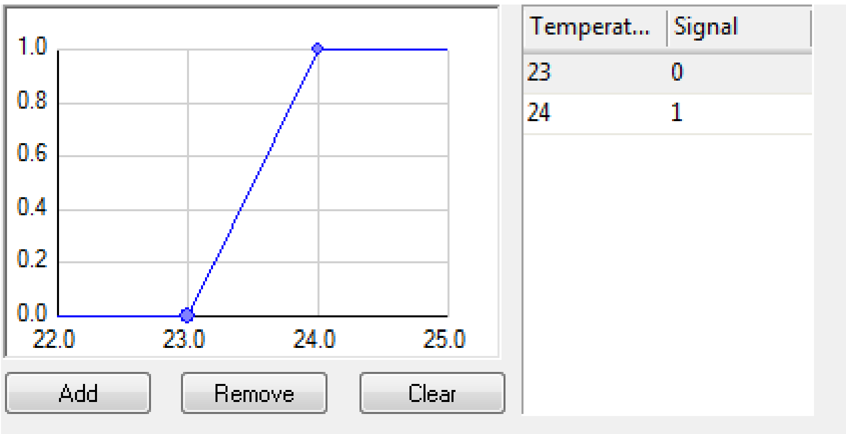

Figure 7: Screenshot showing the profile of the controller.

Using Figure 7, we can see how this profile works. When the air temperature in the zone is below 23 °C, the sensor will read this and pass on this reading to the controller. The Controller will then compare it against this profile and send a signal of zero to the cooling coil, meaning the coil will not operate. For a temperature reading between 23 °C and 24 °C, the controller will read off the signal based on the temperature and pass the signal onto the cooling coil. The coil will then proportion the amount of duty it will provide to meet the load according to this signal. When the temperature reading at the zone is at 24 °C or above, the controller will send a signal of 1 to the cooling coil; this will mean that the cooling coil will work at full capacity. More examples of creating a signal profile with a non-thermostat standard controller can be found in Section 5.

As mentioned before, another way of creating the profile is to go to the Profile tab directly and create it from there. The user can add points to the profile in two ways, by either clicking directly on the profile or by clicking the add button. Upon creating a point the user can edit its position by clicking and dragging it on the profile to the desired position or by editing the points on the table beside the profile graph. For more information on creating the profile for the controller the user can watch the "Systems and Collections - Controls – Profile" video in the TAS Systems User Guide.

Please note that the user can access the Type, Variable and Sensor fields from the Profile tab. Any changes made on this tab will overwrite the inputs on the Setpoint tab and vice versa.

2.3 The Fields Relating to Creating the Signal (Thermostat Standard Controllers)

Now we shall discuss how to create the profile when using Thermostat Standard controllers. With a Thermostat Standard Controller, the profile created by TAS will use the thermostat or humidistat of the zone, set in the zone's internal condition, or the Fresh Air Rate field in the zone component's properties. This is done so users can easily set up their controllers to control to data already entered into the software. The first big difference between the Thermostat controllers and the Non-Thermostat controllers is that the user ***must*** use the fields in the Input box to create the profile. While users will be able to view their profiles and edit the maximum and minimum signal from the profile, the profile itself must be created using the Input fields.

The first thing to do when creating the profile linked to the thermostat or humidistat is to decide on which limit you will use to produce the profile. The user can choose from the following options from the drop down menu that appears next to the Variable field:

Figure 8: Figure showing the additional option that appears when a thermostat option is chosen

- **Lower Limit –** Using this option will mean that the lower limit of the thermostat/humidistat will be used to generate the profile for generating the signal. An example of when you could use this option would be for controllers connected to heating components.
- **Upper Limit –** Using this option will mean that the upper limit of the thermostat/humidistat will be used to generate the profile for generating the signal. An example of when you could use this option would be for controllers connected to cooling components.
- **Lower and Upper Limit –** Using this option will mean that the lower and upper limit of the thermostat/humidistat will be used to generate the profile for generating the signal. It should be noted that this option will generate a profile different to the others as it is generated using the upper and lower limit values along with two associated bands, rather than just the one value and band. The differences this causes will be discussed later on in this subsection, followed by an example. One example of when you could use this option would be to control the fans so that when the temperature of the zone is within the thermostat limits the fans won't operate to provide the zone with conditioned air.

Please note that when using the Min Fresh Air variable you will not be given an option of what limit to create the profile from. This is because the Min Fresh Air variable will always create the profile from the Fresh Air Rate field of the Zone component.

The thermostat/humidistat limit chosen, or the Fresh Air Rate of the zone component, will act in the profile in much the same way as the Value field does for Non-Thermostat controllers. Due to this, the user will not find a Value field in the Input box. With a Thermostat Standard controller, the Input box contains the following fields:

- **Band –** The Band field works in mostly the same way as with Non-Thermostat controllers. The one major difference is the case where the profile is generated using both the lower and upper limits of a thermostat/humidistat. In this instance two bands will be created on the profile, with one for the profile's change at the upper limit and one for the profile's change at the lower limit. It should be noted that the user can enter a band value into the controller such that the two proportional bands from the lower and upper limits will intersect rather than reach the minimum signal of zero. When this happens, the profile will only be able to set the minimum at the intersection point of the two bands. This minimum will produce a signal bigger than 0 (and possibly bigger than a minimum value set in the Minimum field, please see Section 2.4), so it is strongly recommended that the user only enters a band value which does not lead to the two proportional bands intersecting.
- **Gradient –** The Gradient field works in the same way as with Non-Thermostat controllers, although the user should be wary when using both the lower and upper limit of a

thermostat/humidistat to create the profile as there will be two slopes sloping in opposite directions. In this case the choice of gradient applies to the slope starting at the lower limit. This means the "Positive" option will have the signal at max within the limits, while the "Negative" option has the signal at max outside of the limits.

- **Offset –** The Offset field allows the user to offset their created profile by the value entered here. The user can enter a positive or negative value here, allowing them to offset the profile away from the data used to create the profile. When a positive value is entered, all points on the profile will be offset in the positive direction by the amount stated in the offset field, while a negative value would mean that all points are offset in the negative direction.

After the user generates the profile using these options, it is recommended they go to the Profile tab to check the profile is created as they would have expected.

We will now work through an example of how this profile is set up in practice using these fields. Let's take the situation where we want to set up our fans, servicing only one zone, so that they only create an air flow when the zone's air temperature is outside of the lower and upper limit of the zone's thermostat. The air provided to the zone will be conditioned (We will not discuss setting up the controllers to condition the air appropriately here, just the controller connected to the fans. An example of how to set up controllers to condition the air is given in Example 5.2.) to warm or cool the zone to be within the thermostat limits. During hours where the zone's air temperature is inside the thermostat limits, we want the fans to gradually turn off so that no ventilation is provided. We will assume that the difference between the upper limit and lower limit is 4 ^{o}C, meaning that entering a band value smaller than 2 ^{o}C will mean the two bands do not intersect. To set this scenario up, the user would create a controller connected to the fans. A sensor would then be attached to the zone component. In the controller's properties, the Type field would be set to "Normal" while the Variable field would be set to "Temperature (Thermostat)". In the Input Box, the user would enter:

- **Band –** 0.5 (^{o}C)
- **Gradient –** Negative
- **Offset–** 0 (^{o}C)

This will produce the required control strategy, which can be seen by looking at the profile in Figure 9.

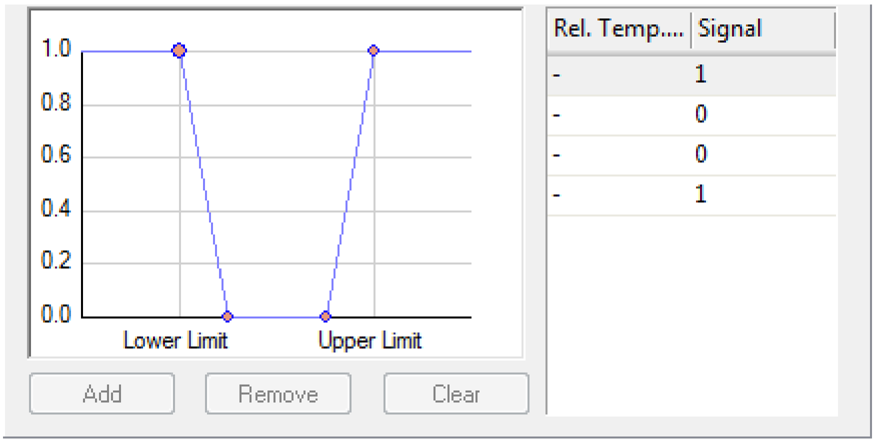

Figure 9: Screenshot showing the controller's signal profile

From the profile we can see that when the air temperature is below the lower limit, or above the upper limit, the controller will send a signal of one to the fans. A signal of one means the fans will provide the maximum flow rate to the zone. Between the thermostat limits the two slopes indicate the fan reducing / increasing the flow rate in correspondence with the temperature of the zone. At the bottom of the slopes the controller will send a signal of zero to the controller. This will tell the fans to not produce any flow at all. The user will find more examples of Thermostat Standard controllers in Section 5.

From the profile page the user can edit the signal produced at each point, for instance in the example above they could enter a signal between zero and one to replace the zero signal as the minimum signal. This would represent a situation where the fans have to provide a minimum amount of air to each zone. Although it can be done from here the user would normally use the Minimum Design Source Field of the fan to set this minimum signal.

2.4 Output: Maximum and Minimum Values

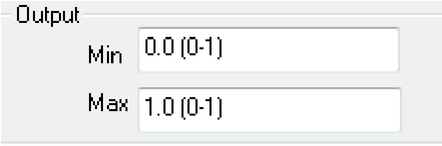

Figure 10: The Min and Max fields of the controller

The Min and Max fields in the Output box allow the user to hand select the minimum and maximum signal a controller will be able to send. This means that instead of editing a profile, the user can enter the minimum and maximum values a controller can send and the profile will be altered to take this into account. It should be noted that fields from certain components, i.e. the Minimum Flow Source field from flow components, have the ability to override any value set in the Min field. This is because these fields work by setting the Minimum signal to alter how the component works. In the case of the Minimum Flow Source field of a flow component, the Minimum Flow Rate through the component is set by working out the signal that will cause this flow rate at the flow component and then setting this as the minimum value the profile can take. To ensure that this minimum flow is met, the component will override any minimum signal set in the controller.

It is recommended that the user checks that they have not set the Min and Max signal to the same value. When this happens the controller will always produce the same signal, as the profile will be equal to the same value at all points.

2.5 Setback Tab and Setback Values

When the user first goes to the Setback tab, all they will find is a Schedule field with a drop down menu for options. The Schedule field allows the user to apply one of the schedules in their system file to the controller to detail its main hours of operation. Upon choosing the schedule, the user will then have to set up how the signal will be produced during out of scheduled hours, also known as setback hours. The setback option works just like the setback option in the building simulator. The user will set up the profile in the same way as discussed before, but the profile will appear on the Setback tab. The required fields to produce the Setback profile in the input box will appear in the space on the right hand side of the box.

2.6 Advanced Settings

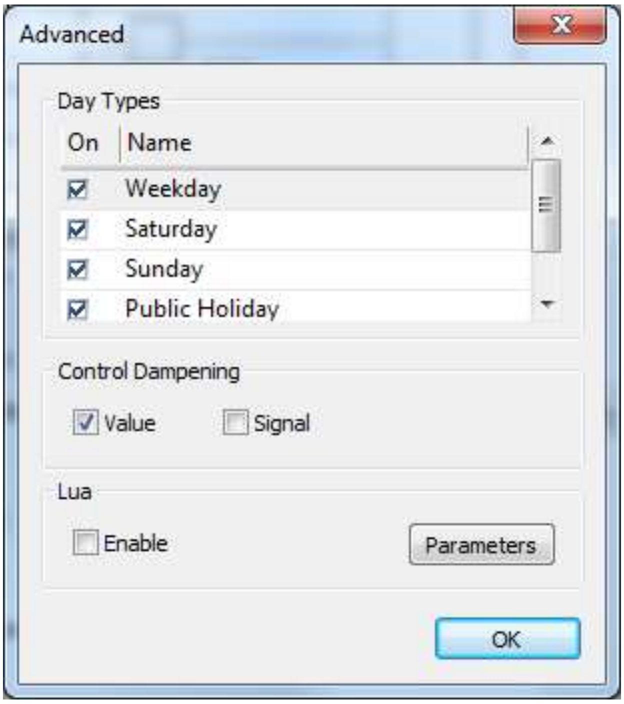

Figure 11: The advanced options dialog for the standard controller

The Advanced settings of a controller allow the user to modify how the controller works. As these are the advanced settings, the user will rarely need to modify the entries kept in this dialog. The three main settings the user can edit from here are:

- **Day Types –** This field allows the user to choose what day types the controller will send a signal to the component. Listed in the box is a list of all day types from the calendar in the Building Simulator file. The user is then able to check the day types they wish the controller to send the signal on, while unchecking the days they wish no signal to be sent. This will mean that the component will not operate on this day type, unless another controller is attached to this component which is sending a signal on this day type. It should be noted that only one controller on any given day type should be sending a signal to the component. Multiple signals being sent on the same day type will lead to the component not acting how the user would expect. Please note that the results of the controller will display a signal of zero for all hours on the days the controller is not operating.
- **Control Dampening –** The calculation of results in TAS Systems is an iterative process, as a change in one component will cause knock on effects all around the system. Due to this iterative process, systems will converge onto an answer to give as a result in this hour. The Control Dampening options allow the user to decide if they wish to use dampening on the sensor and signal calculations. This process should reduce fluctuations in the calculations and converge on a result more quickly. In this field the user is presented with two tick box options for value and signal. Ticking the Value option means that the sensor reading calculations will have dampening to reduce the fluctuations while ticking the Signal option will use dampening with the signal calculations. By default only the Value tick box is ticked.
- **LUA Code –** LUA code is an advanced feature which allows the user to enter LUA code into the software to describe how the controller should work. When enabling this option, by ticking the enable tick box, the user will be presented with a Code tab where the user can enter their own LUA code to set how their controllers work. Alongside the enable tick box is a parameters button. This allows the user to set which options appear in the Properties tab when LUA code is enabled. The user should note that this is an advanced feature which may cause problems. If the user decides to use this feature they should save often and keep

backups. As LUA code will not be used by most users, we will not discuss it any further in this guide.

3 External Controllers

This subsection will talk about External controllers. It will explain what an External controller is, before discussing how to create one. Finally, it will discuss the properties of the External controller.

3.1 What is an External Controller and how do You Create One?

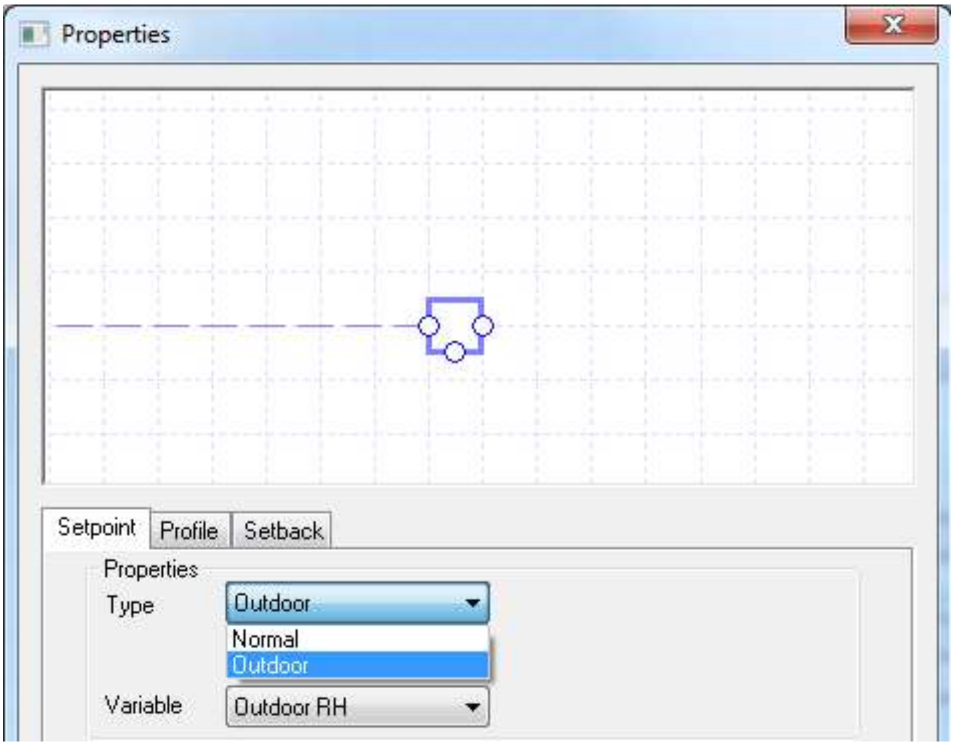

Figure 12: An External controller, with the selection of the Outdoor type displayed.

An External controller is a type of Standard controller that places its sensor externally, rather than placing the sensor on a duct or zone. This means that the user can now control their components based on the external weather conditions, from either the weather data in the TBD file or the conditions entered manually within Systems. Please note that External controllers can be used in both the plant room and air-side systems.

To create an External controller, the user would need to create a controller but not connect any sensors to it. Then, the user needs to open up the controller's Properties dialog and change the controller's type to Outdoor. Please note that if the user places a sensor onto this controller, it will no longer be an External controller and will revert back to being a normal Standard controller.

3.2 External Controller's Properties

As an External controller is a type of Standard controller, we have already discussed most of the available properties in Section 2. In fact, apart from the lack of being able to see the sensor's placement, the only difference in the properties between an External controller and a Non-Thermostat Standard controller of normal type is the available options in the Variable field. There are six different options available to choose from for an External controller, with all options available in both the plant room and air-side systems. The options are:

- **Outdoor Drybulb** – With this variable selected, the sensor will take the external drybulb temperature for the hour as the reading passed onto the controller. This drybulb temperature will be taken from the weather data entered in the TBD file or the external conditions entered manually into Systems; depending on the External Conditions option chosen in the Simulate dialog.

- **Outdoor Hum Rat** – With this variable selected, the sensor will take the external humidity ratio for the hour as the reading passed onto the controller. This humidity ratio will be calculated from the weather data entered in the TBD file or the external conditions entered manually into Systems; depending on the External Conditions option chosen in the Simulate dialog.
- **Outdoor RH** – With this variable selected, the sensor will take the external relative humidity for the hour as the reading passed onto the controller. This relative humidity will be taken from the weather data entered in the TBD file or the external conditions entered manually into Systems; depending on the External Conditions option chosen in the Simulate dialog.
- **Outdoor Enthalpy** – With this variable selected, the sensor will take the external enthalpy for the hour as the reading passed onto the controller. This enthalpy will be calculated from the weather data entered in the TBD file or the external conditions entered manually into Systems; depending on the External Conditions option chosen in the Simulate dialog.
- **Outdoor Wetbulb** – With this variable selected, the sensor will take the external wetbulb temperature for the hour as the reading passed onto the controller. This wetbulb temperature will be calculated from the weather data entered in the TBD file or the external conditions entered manually into Systems; depending on the External Conditions option chosen in the Simulate dialog.
- **Outdoor Pollutant** – With this variable selected, the sensor will take the external pollutant level for the hour as the reading passed onto the controller. Please note that this external pollutant level is set, before a simulation, in the Simulate dialog. As only one value is set, this pollutant level is also constant for the year.

4 Other Types of Controller and Chained Controllers

In the previous sections we have discussed how to set up a standard controller using sensors; however the Standard controller isn't the only controller available to use in TAS Systems. In fact, there are 5 other types of controller to use which all share one thing in common, they use signals created by other controllers as their input to produce a signal of their own, rather than using a sensor reading to produce a signal.

This section will at first talk through how to create these new controllers in TAS Systems. It will then go through and explain each type of controller and give a quick example of when to use each one.

4.1 Creating the New Controllers and Chaining Them

To create one of these new controllers requires the user to have already created a Standard controller, but to have not yet connected a sensor to it. Without the sensor connected, the user will note that there is an additional circular port at the bottom of the standard controller. It is by using this port that the user creates the new controllers.

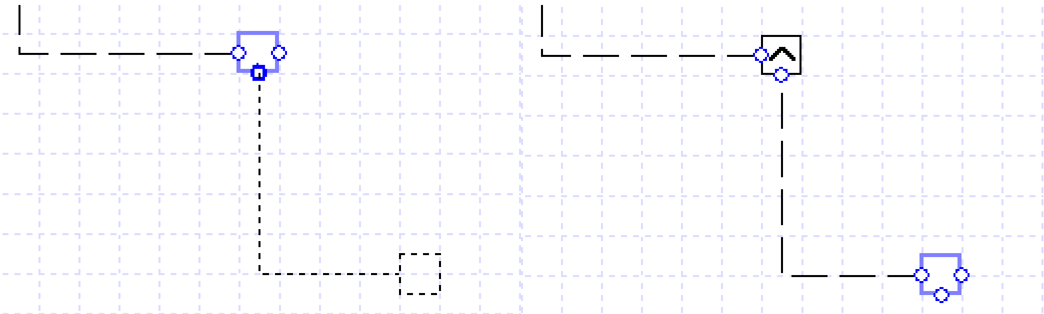

Figure 13: On the left, the new controller being set up by using the additional port at the bottom. On the right, is the finished controller setup. Please note that the original controller is the one that transforms into one of the newer types, not the created one chained to this controller.

To create the new type of controller, the user will need to click and drag on the circular port at the bottom of the controller. This will create a new Standard controller connected to the original controller, which will now have a symbol in it. This is because the original controller has been converted from a standard controller into one of the new types of controller, and the symbol indicates what type of controller it is. It should be noted that any type of controller can be attached to these new types of controllers; all controllers that are attached are referred to as chained controllers.

Upon clicking on the controller with the symbol to open up the properties, the user will see the four available properties. Along with Name, Description and Day Type fields (which works in the same way as the Standard controller's Day Type field) there is a Type field. The user has five choices in this Type field, which will change the method of how the controller produces its signal. These five choices will be discussed in the next subsection.

4.2 The New Controller Types

The five types of new controller all operate in different ways. This subchapter will explain how they all work:

- **The Maximum Controller –**

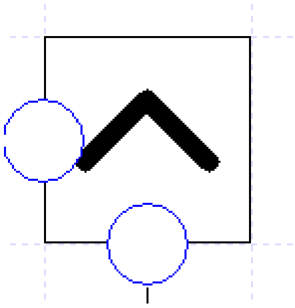

Figure 14: The Maximum controller

The Maximum controller is represented on the schematic by a controller with an upwards pointing arrowhead symbol. As a controller, it takes signals from all controllers chained to it and works out the maximum signal of all these signals. It then uses this maximum as the signal it passes on. It should be noted that a Max controller requires all the signals it receives to be of the same type. So, for instance, you cannot send a signal from a Passthrough controller and a signal from a standard (0-1) controller to the same Max controller. An example of using this controller can be found in Section 5.2.

- **The Minimum controller –**

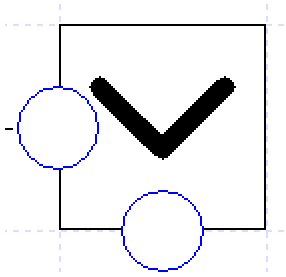

Figure 15: The Minimum controller

The Minimum controller is represented on the schematic by a controller with a downwards pointing arrowhead symbol. As a controller, it takes the signals from all controllers chained to it and works out the minimum signal from them. It then uses this minimum signal as the signal it passes on. It should be noted that a Min controller requires all the signals it receives to be of the same type. So, for instance, you cannot send a signal from a Passthrough controller and a signal from a standard (0-1) controller to the same Min controller. An example of using this controller can be found in Section 5.2.

- **The Not Controller –**

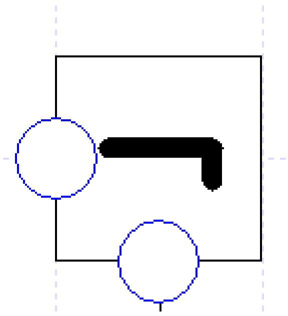

Figure 16: The Not controller

The Not controller is represented on the schematic by a controller with the logical negation symbol. Unlike the Max and Min controllers, it can only have one chained controller connected to it. It works in much the same manner as a not gate in logic, meaning that if the chained controller sends a signal of 1, the not controller will return a signal of zero, and vice versa. Unlike in logic, however, the signal the not controller receives will not always be one or zero. Hence the Not controller returns a signal of:

$$1 - \textit{The signal from the chained controller},$$

for all signals sent by the chained controller.

- **The If Controller –**

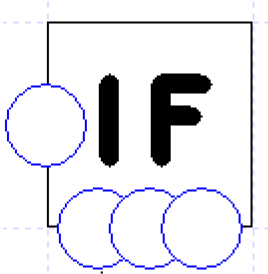

Figure 17: The If controller

The If controller is represented on the schematic by a controller with an IF symbol and allows the user to set up a control system using if statement logic. To do this the If controller requires precisely 3 controllers to be chained to it. Each of the chained controllers must be uniquely connected to the three ports at the bottom of the controller. If more than one controller is chained to one of these ports, the software will inform you of this in the error section and you will not be able to simulate your system.

The If controller works in the following manner. The controller chained to the first port of the If controller (the left port) is the condition controller. When the condition controller sends a signal of 1 to the If controller, the If controller will return the signal of the controller chained to the second (middle) port. When the condition controller returns a signal of zero, the If controller will then return the signal of the controller chained to the third (right) port. In the situation where the condition controller sends a signal between zero and one, the If controller will return the following signal

$$S_1 S_2 + (1 - S_1) S_3,$$

where: S_1 is the signal of the condition (left port) controller, S_2 is the signal of the second chained (middle port) controller and S_3 is the signal of the third chained (right port) controller. The user should bear in mind when using the If controller:

- That if they want the If controller just to return the signals from the second and third chained controllers, then the first controller must be set up to do so. This will mean setting up the condition controller to either have a very small band or a band equal to zero. However it should be noted that using a very small or zero band may end up with the results failing to converge, unless the reading the condition controller is using is constant for the hour (i.e. reading the temperature of the fresh air).
- When using Standard controllers for the second and third chained controllers, the controllers must be sending signals of the same type; i.e. you cannot send signals from a Setpoint Passthrough controller and a standard (0-1) controller. If the standard controllers are not using the same type, then an error will be produced and the user will not be able to simulate their system.

An example of an If controller is shown in Section 5.1 .

- **The Sig controller –**

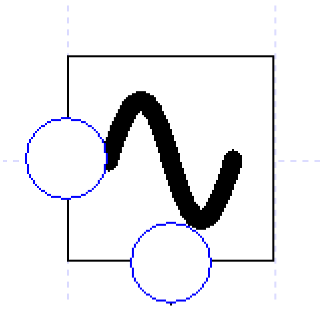

Figure 18: The Sig controller

The Sig controller is represented on the schematic by a controller with a graphical signal profile on it. Like the Standard controller, the Sig controller creates a signal to pass onto the component from a signal profile. However, unlike the Standard controller, this signal is not created by sensors attached to the controller but by the signal sent to it by a chained controller. It should be noted that the Sig controller can only have one chained controller connected to it. When using the Sig controller, the user will need to create the signal profile in the same way as discussed in Section 2.2.

5 Worked Examples

This section of the guide will work through some worked examples which should aid the user's understanding of how the controller set up works.

5.1 High Limit Temperature Shut-Off

What we are trying to model?

In this example, we will model an optimiser with a high limit temperature shut-off in a system with recirculation. We require this optimiser to shut off when the external air's dry bulb temperature is at or above 21 °C. When the optimiser is shut-off, the optimiser will not mix fresh air with the exhaust air to try and temper the air to the supply air's temperature (thus reducing the loads at the coil) but instead recirculate most of the air while bringing in the minimum amount of fresh air required by the zones in this system.

How can we do this in TAS Systems?

This shut off can be easily achieved if we tell the optimiser to mix to the exhaust air's temperature in these shut-off hours. As the exhaust air is already at this temperature, the optimiser will only mix in the minimum amount of fresh air, if a value is set in the Minimum Fresh Air field of the optimiser. However, during normal operation we require the optimiser to mix the fresh and exhaust air together to try and meet the supply air temperature after it has been conditioned; to reduce the loads on the coils doing this conditioning. We can easily tell the optimiser to mix to a certain temperature by using a standard controller of type "Setpoint Passthrough". We can also select what signal to send to the optimiser, based on the external air temperature, by using an If controller in conjunction with a Standard controller of Normal type.

The setup

The If controller set up will be as shown in Figure 19.

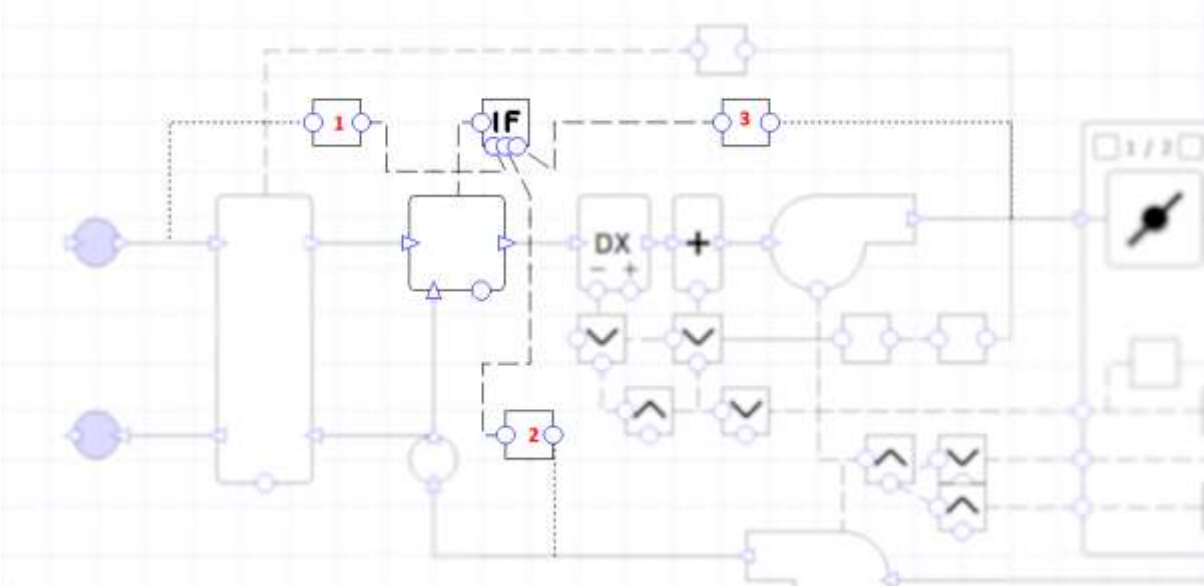

Figure 19: The If controller setup for the high temperature shut-off. Please note that all blurred controllers and components are not used in setting up the shut-off.

The If controller, denoted in Figure 19 as the controller with the symbol "IF", is connected to the optimiser while reading the signals of 3 chained controllers. The first of these chained controllers, labelled 1 in Figure 19, is the controller with its sensor reading the fresh air temperature. To get the results we desire, we want the If controller only to produce the two signals of the chained controllers in the second and third ports. This means that this first chained controller must only produce a signal of zero or one. Also we want the first chained controller to produce a signal of one when the external air temperature is at or above 21 °C and a signal of zero when it is below this temperature, so the If controller takes the correct signal from the chained controllers to use. We also require this controller to be chained to the If controller using the bottom left port, as it is the condition controller. To set up this controller correctly, you will need to use a Standard controller of Normal type. The Variable field in the controller properties should be set to temperature and the sensor should be attached to the duct immediately after the inlet junction. The controller's signal profile should be set up as per Figure 20.

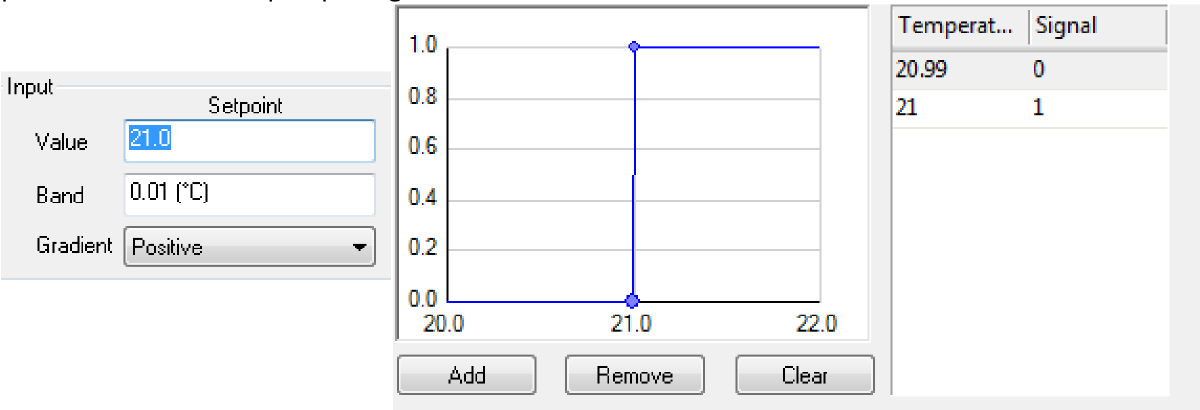

Figure 20: Set up of the fresh air controller, this has a narrow band due to being required to produce a signal of zero and one

The narrow band is required as this controller must only produce a signal of zero or one. A band of 0.01 (°C) is used because in most cases the external air temperature provided from the weather data only gives temperature to one decimal place.

The second of the controllers, labelled 2 in Figure 19 and attached to the middle port, will be used to produce a signal from the exhaust air's temperature. This controller should be a standard controller of type "Setpoint Passthrough" with the Variable field set to "Temperature"; the sensor for this controller should be placed on the exhaust air duct. As we require the use of the exact exhaust air temperature here, the user should not enter an offset on this controller.

The third and final chained controller, labelled 3 and attached to the port on the right, has the same set up as the second controller apart from the sensor is attached to the supply air of the zone, after any conditioning to the air has been done and before the air is supplied to the zone.

How the controls work to achieve this control method

When the external air temperature is below 21 °C, the first chained controller to the If controller will produce a signal of zero. This zero signal is then read by the If controller, which then takes the signal from controller 3 as its signal and passes this onto the optimiser. As the signal from controller 3 is the temperature of the supply air after it has been conditioned, the optimiser will attempt to mix the fresh air and exhaust air to meet this temperature.

When the external air temperature is at or above 21 °C, the first chained controller to the If controller will produce a signal of one. This signal of one is then read by the If controller, which then takes the signal from controller 2 as it's signal and passes it onto the optimiser. As this signal from controller 2 is the temperature of the exhaust air, the optimiser will only add the minimum amount of fresh air mandated at the optimiser to the system, as required by the shut-off.

5.2 Heating and Cooling Setup in a AHU

What we are trying to model?

In this example, we want to model a central AHU supplying conditioned air (hot or cold) to attached zones. The central AHU will have sensors reading the temperature in each zone, while also having a backup space heating device in each zone. This backup heating device will kick in if the AHU can't supply enough hot air to keep the zone's temperature above the lower limit of the temperature thermostat. However, there is no backup cooling device in the space. So if the supplied conditioned air cannot cool the space below the upper limit of the thermostat, the space will overheat. Due to this, we will require that the AHU prioritises any space needing cooling over zones requiring heating as these zones can use their in zone heating component to provide this heating. Also, to stop the zones from potentially overheating, if one zone does not require heating then the AHU should not warm up the supply air.

N.B. It should be noted that we only recommend users put zones with similar demands (roughly requiring heating or cooling in the same hours) on the same system. In previous versions of TAS, the user would also have to set up another controller so they could control the temperature the supply air was being supplied at. Since V9.2.1.7, this no longer needs to be done as all coils now have an Offcoil property which limits the maximum or minimum temperature the coils can heat or cool to.

How we can do this in TAS Systems?

To know when to heat and cool the air depending on the zones demands, we are going to need to attach 2 controllers to each zone. Each controller will need to read the zone's dry bulb air temperature and produce a signal based on either the upper or lower limit of the zone's thermostat. We will need one controller that produces a signal of 1 when the zone requires heating (a heating controller) and another that produces a signal of 1 when the zone requires cooling (a cooling controller). This can easily be done with a Standard controller using the thermostat options to produce a signal.

Prioritising the cooling load over the heating load requires more thought. Firstly, the coils cannot be directly attached to all the appropriate controllers. Having multiple controllers connected to one component will lead to the component being controlled incorrectly. We will need to collate all the results from the controllers reporting the signal for heating and cooling separately and then get one signal out from them. This can be done with Max and Min controllers. With the AHU, we want the cooling coil to operate when **one** of the zones has a cooling demand. This will mean we will want to take the maximum signal produced from any of the cooling controllers and pass that onto the cooling coil. The Cooling coil will then proportion its load in relation to this signal and cool the air down to condition this space. This can be easily done by using a Max controller. While with the heating coil, we only want it to operate when **all** of the zones have a heating demand. This means that we want to take the minimum signal produced from each zones heating controller, as if a zone doesn't require heating there will be a zero signal produced by the heating controller. This can be easily done by using a Min controller. Using the Minimum and Maximum controllers like this means that the AHU prioritises cooling over heating, as required.

It should be noted that when setting up the bands in the heating and cooling controllers, that these bands should never overlap in such a way that both controllers will produce a non-zero signal in the same hour. Doing this could lead to the supply air being heated and cooled in the same hour, wasting energy and slowing down the simulation at the same time.

The setup

The controller set up for the coils will be as in Figure 21:

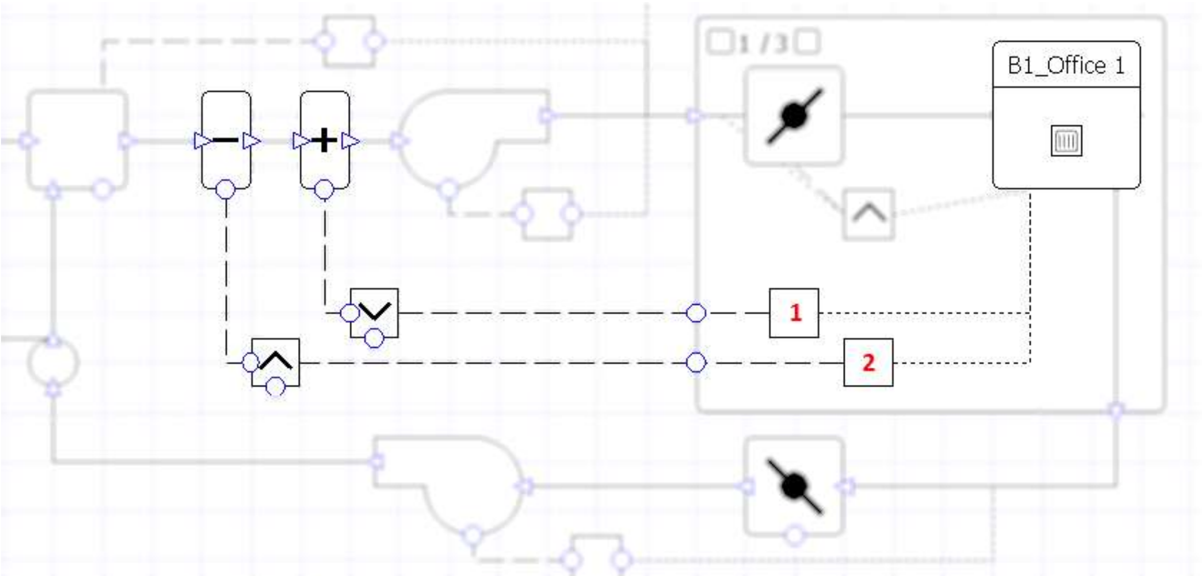

Figure 21: The controller setup for the heating and cooling coils in the AHU. Please note that all faded components are not required in this setup.

Please note that the controllers, labelled 1 and 2 in Figure 21, are unique to each zone. As the AHU has been modelled using a group of zones, each zone will have two similar controllers attached to it.

The controller with label 1 in Figure 21 is the heating controller for that zone. The controller is a Standard controller of Normal type. Its Variable field is set to “Temperature (thermostat)” and it is producing a signal profile using the lower limit of the zone’s temperature thermostat. Its one sensor is attached to the zone and is reading the dry bulb temperature of the zone. The profile is set up as shown in Figure 22.

Figure 22: Setup of the heating controller in Example 5.2.

As you can see from Figure 22, the profile works in the following way. The controller will produce a signal of one when the temperature is below the lower limit of the thermostat. The produced signal reduces, as does the requirement for heating, as the room increases in temperature until the zones temperature is 0.5 °C above the lower limit. At this temperature, the signal reaches the minimum and stays there for any higher temperature.

The controller with label 2 is the controller producing the cooling signal for that zone. The controller is a Standard controller of Normal type, like controller 1, and its sensor is attached to the zone. The controller also has its Variable field set to “Temperature (Thermostat)”; however as it is the cooling controller it produces the signal using the upper limit of the zone’s temperature thermostat. The profile is set up as shown in Figure 23.

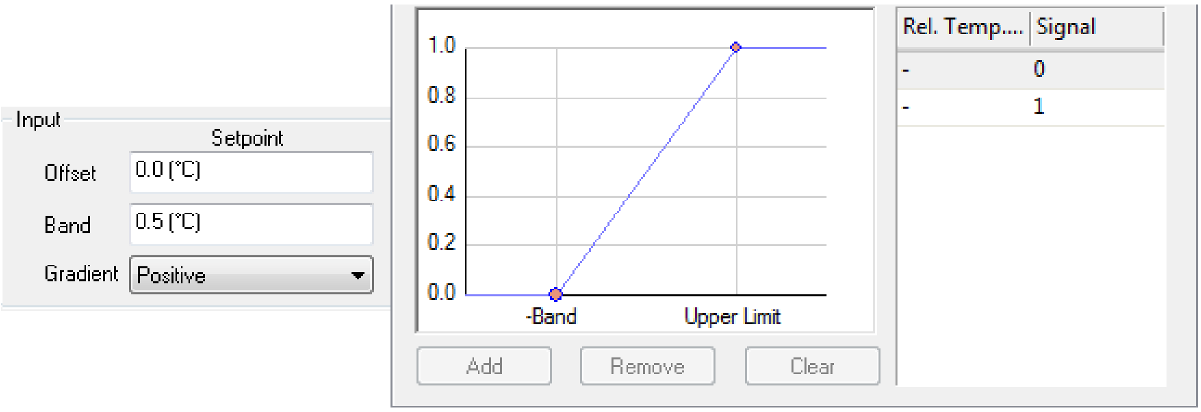

Figure 23: Setup of the cooling controller in Example 5.2.

As you can see from Figure 23, the profile works in the following way. The controller will produce a signal of one when the temperature is above the upper limit of the thermostat. The produced signal reduces, as does the requirement for cooling, as the room decreases in temperature until the zone's temperature is 0.5 °C below the upper limit. At this temperature, the signal reaches the minimum and stays there for any lower temperature.

So now we have set up the heating and cooling controllers, all that needs to be done is to connect them up. For the cooling control we need to connect all the cooling controllers up to a Max controller which in turn is connected to a cooling coil. Similarly we need to connect all heating controllers up to a minimum controller which in turn is connected to a heating coil. The user should note that when using a group of components to represent multiple zones, they would set up one heating and cooling controller connected to Min and Max controllers along with sensors connected to the zone component. They would then group the controllers with the zone component and apply a zone group to the grouped controllers. This will model the multiple zones, with multiple controllers feeding into a Max or Min controller.

<u>How the controls work to achieve this control method</u>

When all zones are below the lower limit of their thermostats, their heating controllers will send a signal of one to the Min controller while the cooling controllers will send a signal of zero onto the Max controller. Due to this, the Min controller will send a signal of one to the heating coil and the Max controller will send a signal of zero to the cooling coil. This will mean that the AHU will heat the air to condition the spaces but will not cool it.

In the situation where one (or more) of the zone's temperature goes above the temperature lower limit + 0.5 °C, the heating controller of the zone will produce a signal of zero. When all the heating controller signals are passed onto the Min controller, this signal of zero will ensure that the Min controller sends a signal of zero to the heating coil. This means that the heating coil will not heat the air so that it doesn't overheat the zone not requiring heating. The in-space heating components will have to cover this heating demand.

In the situation where one (or more) of the zone's temperature goes above the temperature upper limit – 0.5 °C , the heating controller of this zone will produce a signal of zero (as the bands do not overlap) while the cooling controller will produce a non-zero signal. This means that the Min controller connected to all heating controllers will pass a signal of zero onto the heating coil while the Max controller will pass the non-zero signal onto the cooling coil. This means that the supply air will be conditioned by the cooling coil to cool down this space. Other zones which may be cooled to below their heating setpoint will be warmed back up by their in space heating component. Please note that normally, there would be other measures involved to make sure this cool air doesn't affect the temperature of the space too much, for instance a variable air flow rate where each zone can turn down the flow itself, like discussed in example 4.3.

In the final situation, where all zones are within the thermostat limits and bands, all heating and cooling controllers will produce a signal of zero. This would mean that a signal of zero would be passed onto the coils by the Max and Min controllers and the supply air would not be conditioned.

5.3 Varying Flow Rate at the Damper

What we are trying to model?

In this example, we want to model a variable air flow system with two central fans in an AHU where each zone can reduce the air flow rate down to a specified minimum flow rate if necessary. We want the air flow to be at this minimum level when the zone's dry bulb temperature is between the upper and lower limit of the zones thermostat, meaning that no conditioned air needs to be added to the space. Also, in Example 5.2, it was mentioned that you can reduce the air flow when a zone, requiring heating, receives cold air as the AHU is trying to meet a cooling demand in another zone. This additional control will also be modelled on this system.

How can we do this in TAS Systems?

To vary the air flow rate in TAS Systems requires the use of dampers or fans. In our example, the fans will be in the central AHU while there will be dampers local to each zone after the air is split to be sent to each zone (not having the dampers would cause inconsistent design flow rate errors upon simulation). Using the fans in the central AHU will be problematic with our desired control scheme. The fans would need to receive one signal based on all the signals coming from each zone, using Max and Min controllers. However we wish to reduce the air flow rate if cold air is being supplied to a zone needing heating, which would not be possible to do as the fan can only reduce or increase for all zones, not just for one. Hence we will need to vary the flow rate using the dampers.

To set up this control method will require 5 controllers. The first controller will be a controller set up to maximise the air flow rate when a zone requires heating. However, we want to be able to override this controller's signal if the AHU is cooling the air. To do this, we need another controller which is reading the temperature of the supply air entering the zone. This controller should send the minimum possible signal (Set by the Minimum Flow Rate field of the damper and corresponds to the damper allowing air into the zone at the minimum flow rate.) if the air has been cooled and a non-zero signal otherwise. Both of the above controllers should then be connected up to a Min controller. Using the Min controller means we have the override. If the supply air has been cooled when the zone requires heating, the supply air controller will send the minimum signal to the Min controller. This will be eventually passed onto the damper which will restrict the air flow to the minimum flow rate. Similarly, if the supply air has not been cooled then the supply air controller will send a signal of 1, meaning that the heating controller's signal will be the signal that decides the flow rate if the zone requires heating.

The purpose of the other two controllers is more clear cut. There is a controller set up to maximise the air flow rate when a zone requires cooling (As the AHU is prioritising cooling loads, the supply air will be cooled if requiring cooling). Finally there will be a Max controller, reading the signals of the cooling controller and the Minimum controller. The Max controller will take the maximum of these two controllers and pass on this signal to the damper, which will accordingly proportion the air flow based on the signal.

The setup

The Controller setup for the damper will be as in Figure 24.

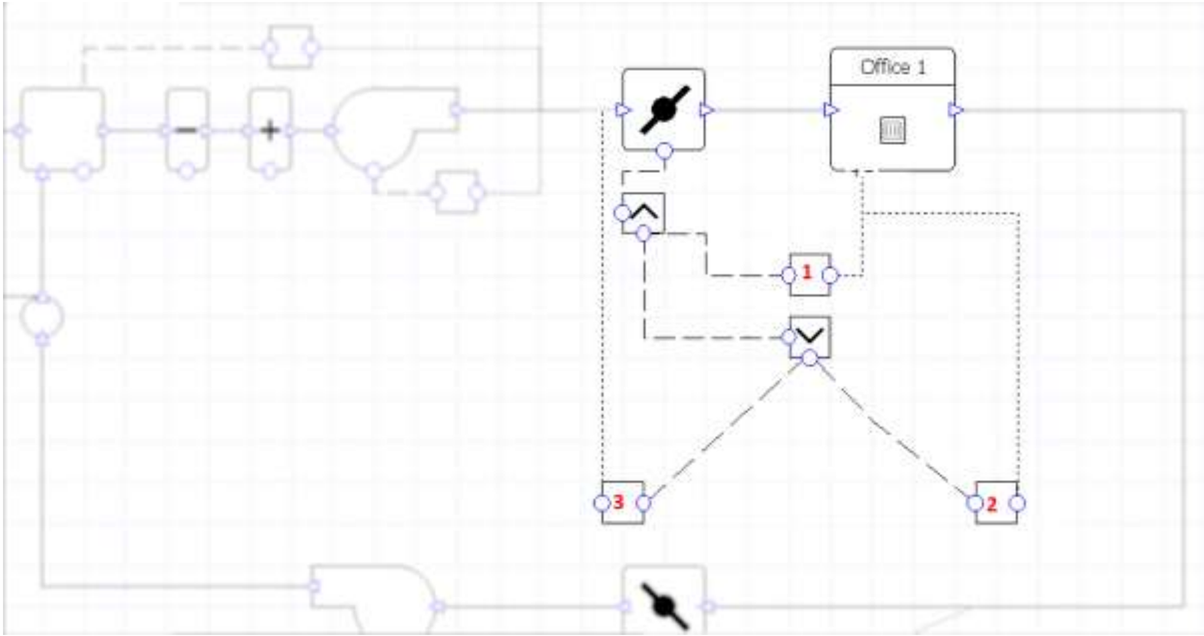

Figure 24: The controller setup on the damper for varying the flow. It should be noted that the heating and cooling controllers attached to the zone have been deleted rather than unfocused in the figure. This is to aid the user's understanding of the dampers controller's setup.

All of these controllers are unique to each zone and should be set up before being grouped together with the damper and zone component to model an AHU servicing multiple zones (Figure 24 does not have the AHU setup so the user can see how to set up each controller before grouping them up).

The controller, labelled 2 in Figure 24, is the heating controller. The controller is a Standard controller of Normal type. The Variable field of the controller is set to "Temperature (Thermostat)" and it is producing a signal based on the lower limit of the zone's temperature thermostat. The controller's sensor is attached to the zone and the profile is as shown in Figure 25.

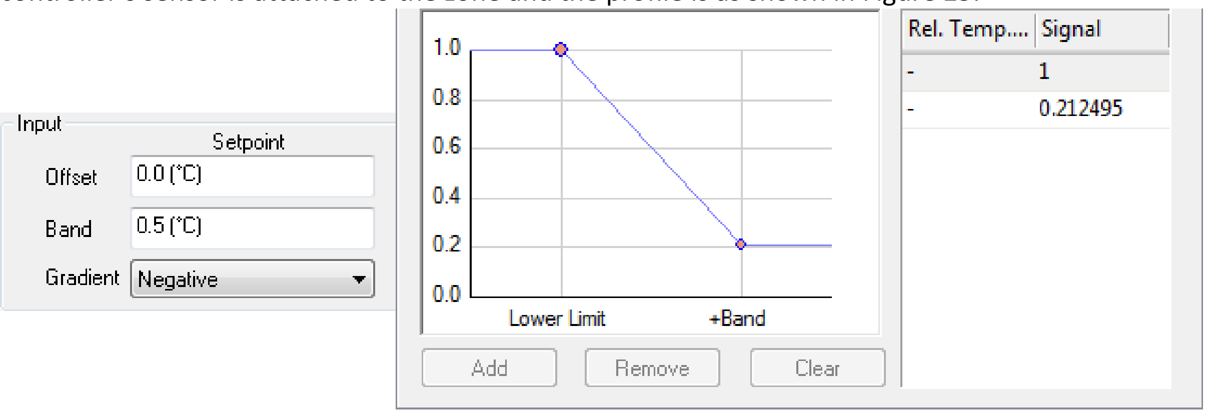

Figure 25: The heating controller setup for when the damper is varying the air flow.

The first thing you may notice is that the minimum signal is not zero. This minimum signal corresponds to the signal required by the damper to produce an air flow rate equal to the value entered in the Minimum flow Rate field of the damper. This converted signal is placed by the software as the minimum signal to ensure the flow rate doesn't drop below this value (If no minimum flow rate is set at the damper, then the minimum signal will be zero). The profile works in the following way. The controller will produce a signal of one when the temperature is below the lower limit of the thermostat. The produced signal reduces, as does the requirement for heating, as the room increases in temperature until the zone's temperature is 0.5 °C above the lower limit. At this temperature, the signal reaches the minimum and stays there for any higher temperature.

The controller, labelled 3 in Figure 24, is the controller that will close the damper down, reducing the flow rate to the minimum flow rate, if cool air is provided by the AHU when the zone requires heating. This controller will be a Standard controller of Normal type with the Variable field set to “Temperature”. The sensor of the controller is placed in the supply air of the zone. It should be noted that the signal profile should be based on the lower limit of the zone’s thermostat, however as the sensor is not connected to the zone it cannot use the thermostat option. Instead you must manually check and enter the value here; in our example this value will be 21 °C with no setback. If the user has a setback on their thermostat, then they should use the setback option on the controller to produce a signal during setback hours. The profile is as shown in Figure 26:

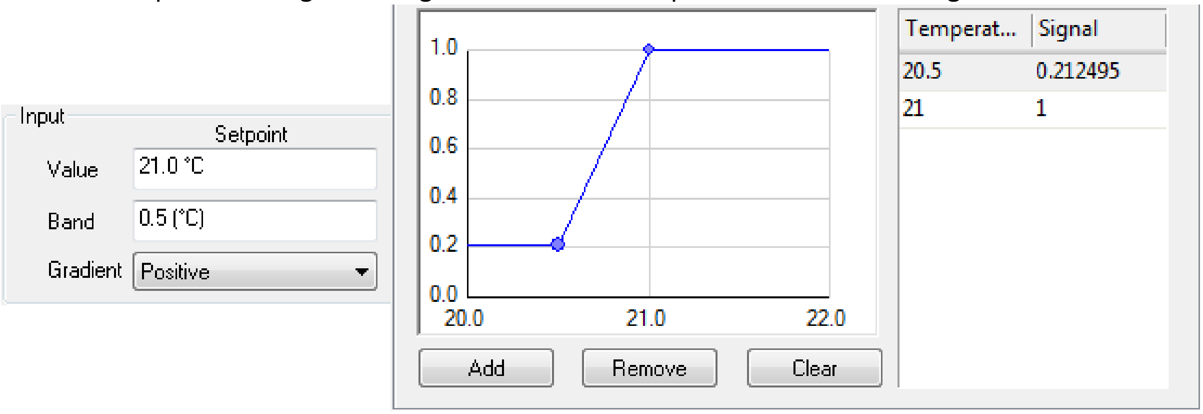

Figure 26: The signal profile setup of controller 3.

With this profile, the controller produces the minimum signal for all temperatures below 20.5 °C. At 20.5 °C, the signal generated by the controller will start to increase until at 21°C the signal produced will be 1. Controllers 2 and 3 will then be chained up to the Min controller, as in Figure 24, which is in turn chained up to a Max controller along with the controller labelled 1 in Figure 24. Controller 1 is the zone’s cooling controller and it is a standard controller of Normal type. The controller’s sensor is attached to the zone and the Variable field of the controller is set to “Temperature (Thermostat)” while producing the signal profile using the upper limit. The signal profile is set up as in Figure 27.

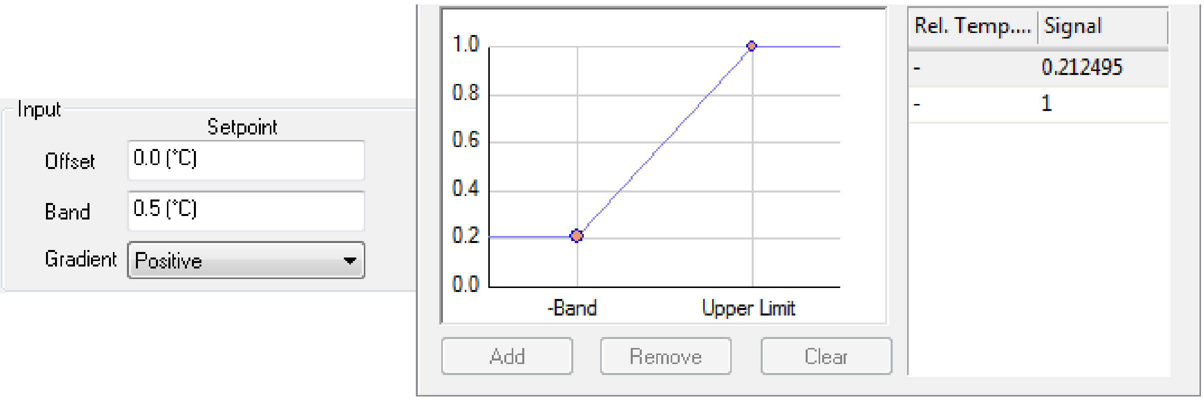

Figure 27: Profile setup of the cooling controller

Looking at Figure 27, you can see the profile works in the following way. The controller will produce a signal of one when the temperature is above the upper limit of the thermostat. The produced signal reduces, as does the requirement for cooling, as the room decreases in temperature until the zones temperature is 0.5 °C below the upper limit. At this temperature, the signal reaches the minimum and stays there for any lower temperature.

Finally the Max controller, with the Min and cooling controller attached, should then be connected to the damper. The damper will then act accordingly based on the signal sent by the Max controller.

How the controls work to achieve the control method

When the zone has a heating demand and the AHU is supplying hot air, the heating controller will return a signal of one while the controller monitoring the supply air will also return a signal of one. This means the Min controller will pass onto the Max controller a signal of one, the maximum possible signal (The cooling controller would return the minimum signal, as the bands of the heating and cooling controller should not overlap). This signal of one would be passed onto the Damper, which will allow the maximum flow rate of air into the zone. As the air has been heated, this will heat up the zone.

When the zone has a heating demand and the AHU is supplying cold air, the heating controller will return a signal of one while the controller monitoring the supply air will return the minimum possible signal. Similarly the cooling controller will also return the minimum possible signal. With the control method set up, the heating controller and supply air monitoring controller would pass their signals onto the Min controller, which would take the minimum signal from the supply air controller. This signal would then be read by the Max controller, which would also read in the minimum signal from the cooling controller. As both controllers pass on the same minimum signal, the Max controller will pass this minimum signal onto the damper. Thus the damper will only allow the minimum amount of ventilation into the zone, stopping lots of cold air entering the zone as required.

When the zone has a cooling demand, the cooling controller will produce a signal of one. The heating controller however returns the minimum signal. This minimum signal when passed onto the Minimum controller will mean that the Max controller has to take the maximum of the minimal possible signal or the maximum possible signal. The max signal will thus be passed onto the damper, which will allow the maximum flow rate of air into the zone. As the air has been cooled, this will have a cooling effect on the zone.

When there is no requirement for heating or cooling in the zone, both the heating and cooling controller will return the minimum signal. This will then mean that the Max controller will pass on the minimum possible signal to the zone and thus the damper will restrict the air flow down to the minimum flow rate.

5.4 Pressure Drops with Dampers

What are we trying to model?

In this example, we are going to model a traditional VAV setup with varying terminal dampers and a static pressure supply fan. As Examples 5.2 and 5.3 deal with the setting up of the controllers for the AHU coils and varying terminal dampers, this example will only deal with how to set up the controllers on the fans, which are monitoring the pressure. The static pressure supply fan will be pressurising the air to roughly 800 N/m^2 and will work with the other components to ensure that the air in the zone is slightly pressurised, with a maximum pressure of around 5-10 N/m^2.

How can we do this in TAS Systems?

The setup required to produce the slightly pressurised air involves the use of pressure drops at the dampers and optimisers, along with two standard controllers, which are placed on the supply and extract fans. The first thing we shall discuss is the setup of the Pressure and Pressure Drop fields of the components. We have two fans, a supply fan and an extract fan, which have fan pressures of 1200 N/m^2 and 900 N/m^2 respectively. The damper varying the flow rate before each zone, which is unique to each zone, will have a design pressure drop of 795 N/m^2. The extract damper, on the exhaust air of all zones, will have a design pressure drop of 605 N/m^2. Finally the optimiser, which is mixing fresh and re-circulated air together, will have a design pressure drop of 100 N/m^2.

The first standard controller, on the supply fan, must ensure that the supply air after leaving the supply fan has a pressure of 800 – 805 N/m^2 during all operational hours. Doing this should mean that the pressure the fan provides is fairly static for all flow rates. Also, it will mean that when the air flow rate is equal to the design flow rate the air will be supplied to the zone at around 5-10 N/m^2, as the supply dampers before each zone all have a design pressure drop of 795 N/m^2. In this example, the design flow rate will be the maximum air flow rate. This means that when the supply dampers close, to reduce the flow rate, the damper will cause a pressure drop bigger than the design pressure drop. This means air flowing at the design flow rate will be at the maximum possible supply pressure.

The second controller is attached to the extract fan and is used to turn the fan down when the supply damper is closed. It is also used, in conjunction with the pressure drops and the supply fan's controller, to keep the supply air slightly pressurised before being provided to the zone. The controller is using a sensor to sense the air pressure before the extract damper, and will tell the fan to turn up gradually as the pressure increases over 5 N/m^2.

This set up, with the pressure drops and the controllers on the fans, will ensure that the air to the zone is slightly pressurised with a maximum pressure of 5-10 N/m^2.

The setup

The setup will be as shown in Figure 28.

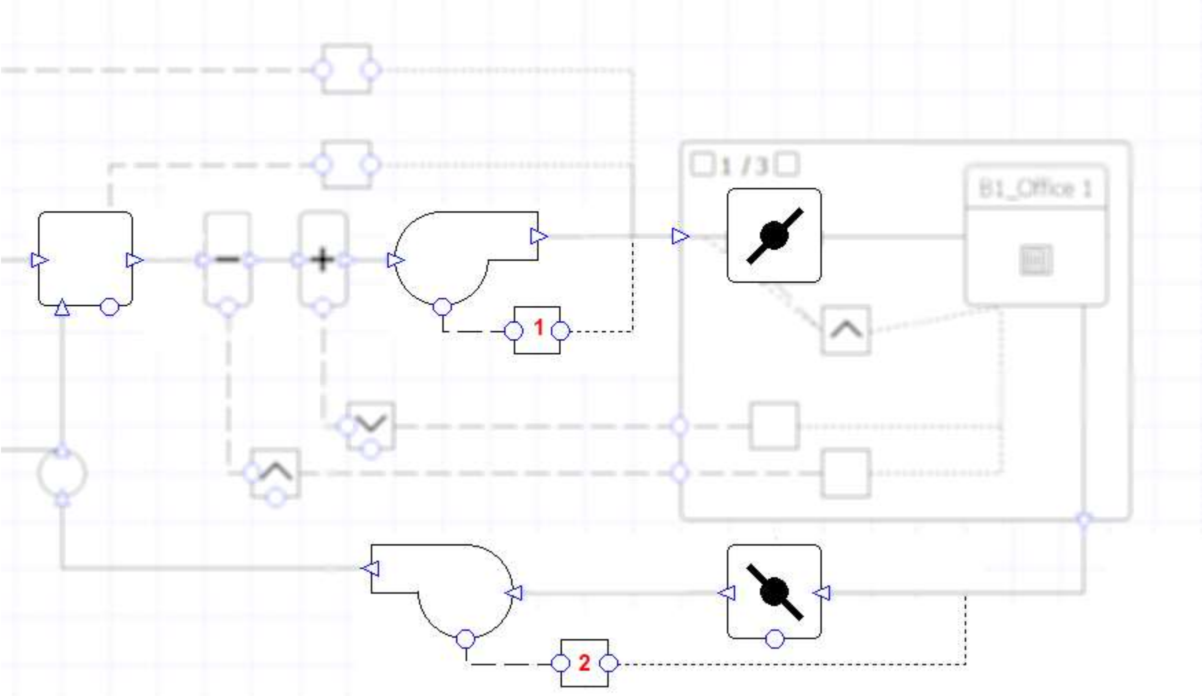

Figure 28: The setup of the controllers for controlling the pressure around the circuit. The dampers have not been faded out in this image as they are causing the pressure drops.

The controller connected to the supply fan, labelled 1 in Figure 28, is the controller ensuring the fan provides a pressure of between 800-805 N/m^2 at all air flows. The controller is a Standard controller of Normal type, its sensor is on the duct immediately after the fan and the sensor is reading the duct's pressure. The signal profile is set up as in Figure 29.

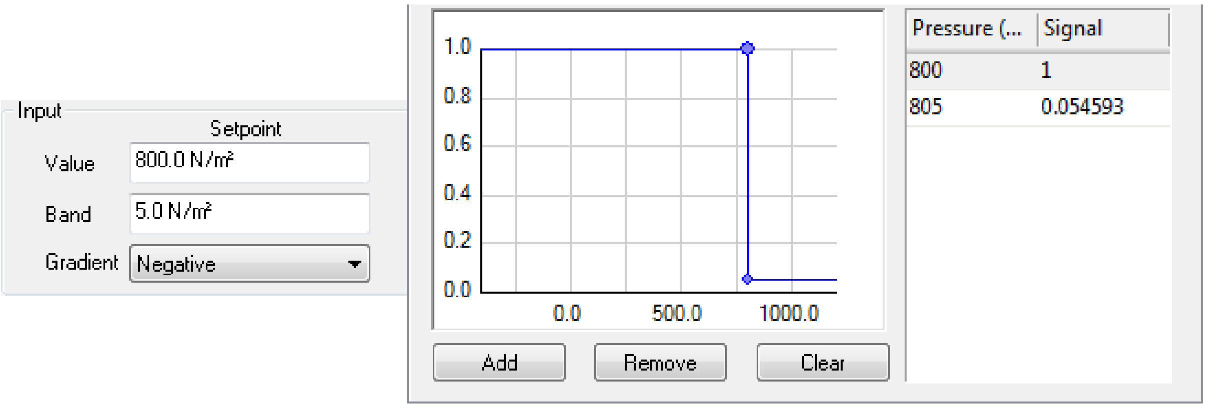

Figure 29: The profile setup of the controller connected to the supply fan

The controller will produce a signal of 1 until the supply air's pressure is at 800 N/m^2. From this point, the signal will steadily decrease until at 805 N/m^2 onwards it produces the minimum possible signal. This minimum possible signal will correspond to the minimum flow rate the fan can provide. As we are varying the flow rate with dampers in this example, the minimum flow rate the fans can provide will be the sum of the minimum flow rate of each attached damper.

The controller labelled 2 in Figure 28 is the controller connected to the extract fan. This controller is a Standard controller of Normal type with its sensor placed before the extract damper. The sensor is reading the pressure of the air flowing through the duct. The controller's signal profile is set as in Figure 30.

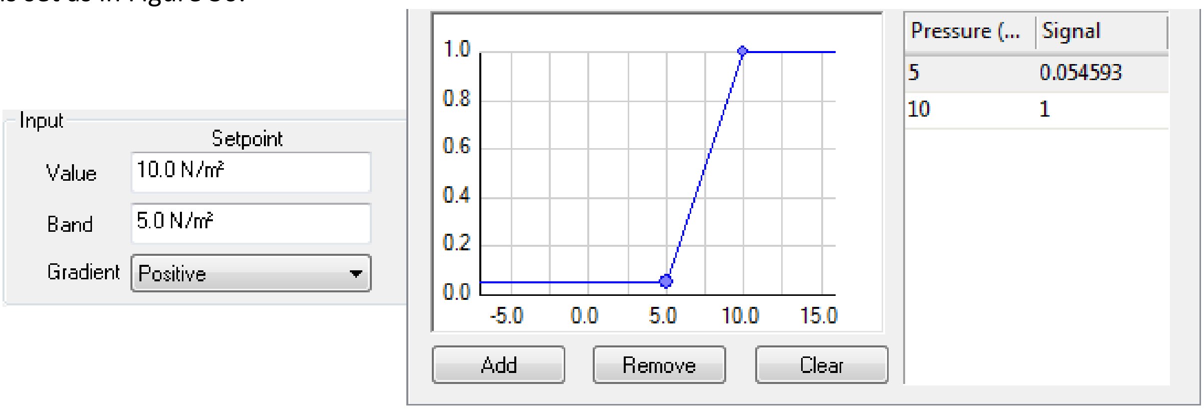

Figure 30: The profile setup of the controller connected to the extract fan

The controller will return the minimum signal when the air in this duct's pressure is at or below 5 N/m^2. This will steadily increase with pressures above 5 N/m^2 until the pressure of the air is at or above 10 N/m^2, where the controller will return a signal of one.

How the controls work to achieve the control method

The controller on the supply fan will ensure that during all hours the fans operate the air will be leaving the supply fan at a pressure between 800 – 805 N/m^2 at all flow rates. Maintaining the air at this pressure will mean that when the supply damper closes to vary the flow rate, the supply fan will turn down to save energy rather than try to increase the pressure of the air flowing through it (i.e. a static pressure supply fan). Also, when the air flow is at the design flow rate, which will be the maximum flow rate for this system, the air pressure of the air supplied to the zone will be between 5-10 N/m^2. As the pressure drop will be bigger at the supply damper for reduced air flows, the maximum pressure the supply air can take is between 5-10 N/m^2, as required. The second controller is also set up to turn the fan down to save energy. In this instance however, it will turn down when the air is only marginally pressurised and turn up gradually when the air pressure is 5 N/m^2 running at maximum when the pressure is 10 N/m^2.

The first controller will, along with the second controller and the pressure drops modelled by the dampers and optimisers, work to also make sure that the supply air is always slightly pressurised. This can be seen by checking the air pressure on the duct before the zone; the maximum value will be between 5-10 N/m^2, while the minimum value will be zero (which occurs when the fans are turned off).