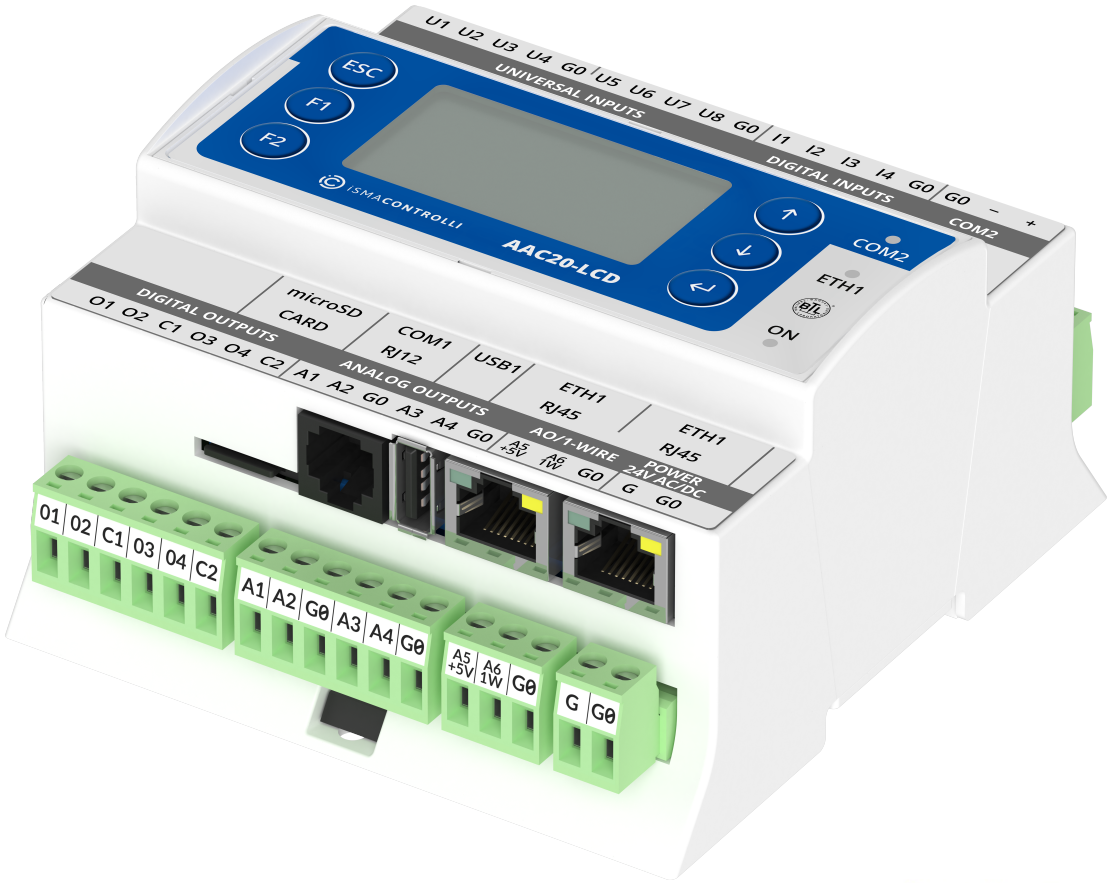
iSMACONTROLLI

iSMA-B-AAC20

User Manual

AHU Application



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1 Introduction

The AHU application allows for the use of a wide variety of ventilation systems containing water heaters, water coolers, humidifiers, heat exchangers, or mixing dampers.

Thanks to its versatility, the application allows to configure a number of types of popular ventilation systems, which will be discussed in the following sections. The application can be configured from the LCD level, the AAC20 web server, via the BACnet IP/Modbus TCP protocol or from the iC Tool level. The detailed parameters required to adjust the application to the specific requirements of the ventilation system onsite are available only from the iC Tool level.

1.1 Revision History

Rev.	Date	Description
1.0	19 Jul 2024	First edition

Table 1. Revision history

2 Installation

Before the installation, make sure that the following prerequisites are fulfilled:

- SD card to store the web server application is in place - minimum required SD card capacity is 4 GB, recommended maximum capacity is 32 GB;
- kits required to load the application are installed using the Kit Manager on the AAC20 controller:
  - iSMA_LCD (required even in AAC20 controllers without an LCD display);
  - iSMA_localIO;
  - iSMA_ModbusAsyncNetwork;
  - iSMA_ModbusTcpSlaveNetwork;
  - iSMA_BACnet;
  - iSMA_VisualizationWebServer.

Figure 1. Kits required to install for AHU application

3 Application

In order to install the application, first, download it from the website: support.ismacontrolli.com, extract it, and save it in the appropriate iC Tool folder (home/Applications).

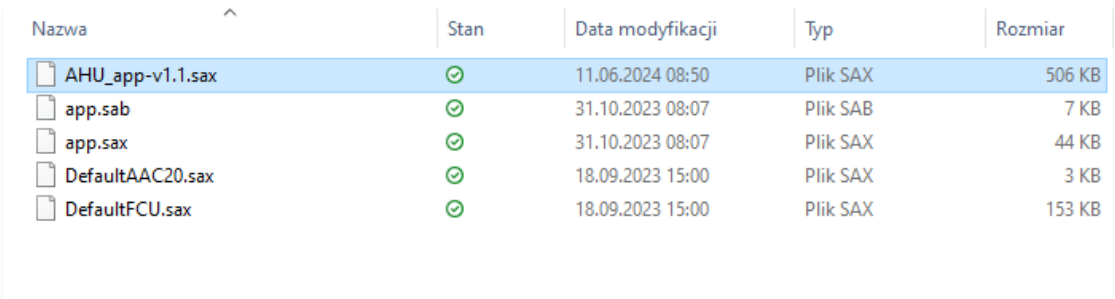


Figure 2. AHU application in the iC Tool folder

Next, run the iC Tool and connect to the AAC20 device, logging in as an administrator.

Note: If the iC Tool has already been running, it needs to be restarted.

After logging in, go to the Application Manager, select the AHU application from the list of available applications, and load it to the selected device using the Put App command.

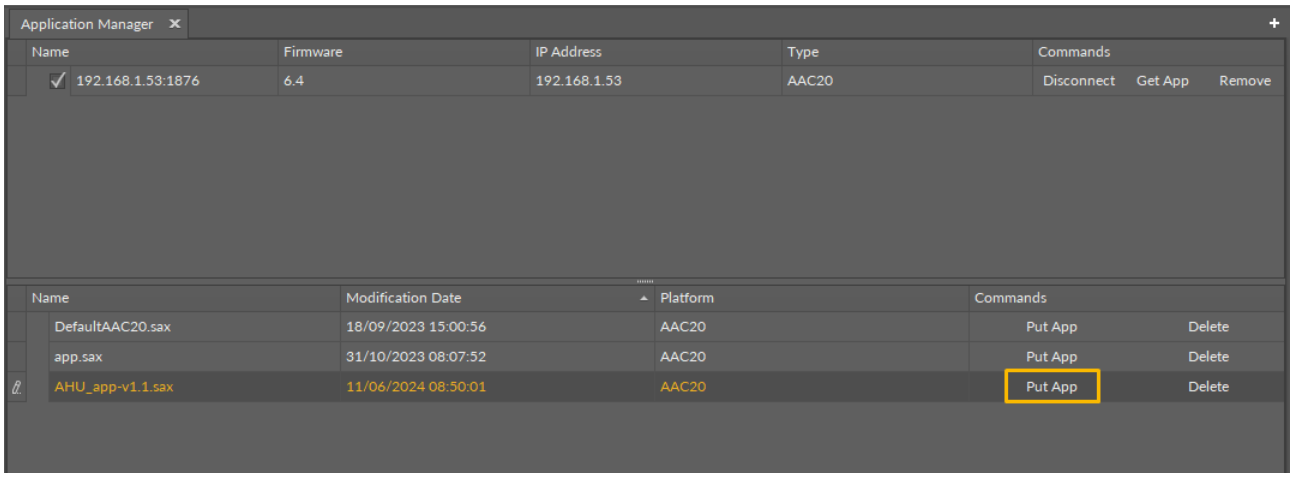


Figure 3. AHU application in the Application Manager

To complete the upload process, the device restarts and requires to log in again. Default authorization data:

- User - admin
- Password - (none - leave empty)

Then, it is also required to additionally load the default values to the NV variables (using the CopyFromDefaultToNv action available on the plat component under app\service\).

Note: Moreover, it is recommended to set all NV variables to work in an automatic mode using the SetAllNVInAuto action available in the plat component under app\service.

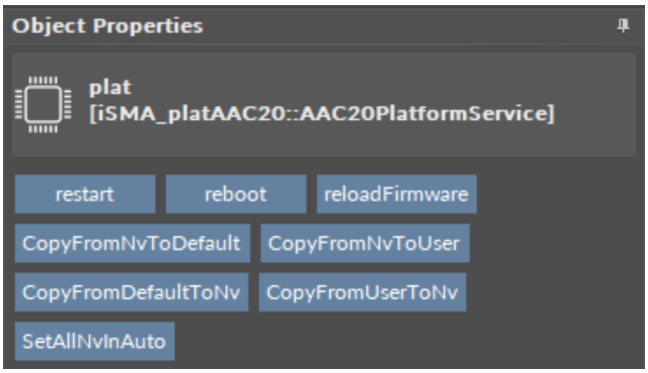


Figure 4. Actions available for the plat component

4 Quick Start-up

To start using the AHU application, follow these steps:

Step 1: Make sure to have installed a working environment for the AAC20, the latest version of the iC Tool software.

Step 2: Go to the support.ismacontrolli.com website and download the AHU application bundle. Extract the files in the iC Tool folder.

Step 3: Open the iC Tool program and connect to the AAC20 controller.

(a) Go to the Kit Manager and make sure that all required kits are installed.

(b) Go to the Application Manager. Using the PutApp command upload the AHU_v1.1.sax file to the controller.

Step 4: Proceed to configure the application. All parameters available to configure for the AHU application are listed in the Configurable Parameters chapter. Configuration can be performed using either one of three methods: web server, LCD display, or the BACnet IP/ Modbus TCP/IP protocols (remotely/directly from the BMS system).

(a) **Web server:** follow the instructions available in the Web Server chapter: copy a selected AHU application example or an individually prepared pattern based on General Files to the main level tree of the SD card, upload the index.html file using the AAC20 Updater, open the web server in the browser, and proceed to configuration;

(b) **LCD display:** follow the instructions available in the LCD chapter: go to the LCD display of the AAC20 controller and proceed to configuration.

It is recommended to use one of configuration patterns prepared in the AHU application examples.

Step 4: Once all the parameters are configured, the AHU application is ready to use.

5 Inputs and Outputs

The arrangement of inputs and outputs signals described below is dedicated for the AHU application specifically. This configuration cannot be changed without risking an incorrect operation of the AHU application. Most of available sensors are active in the application for specific functionalities depending on the type of sensor, e.g., connecting a mixing temperature sensor impacts a control of mixing dampers. Some of the sensors are indispensable for the operation of the AHU application, depending on the selected configuration, while the rest can be used optionally if additional functionality is required, e.g. a CO_2 concentration sensor affecting the control of mixing dampers.

5.1 AAC20 Built-in I/O

1. U1 – Discharge Air Temperature: required to perform a proper discharge air temperature control function, the absence of the sensor does not stop the AHU system, but results in full opening of the heater and exchanger control;
2. U2 – Return Air Temperature: required to perform the discharge air temperature control based on the return air temperature - only for supply and exhaust air handling units;
3. U3 – Outside Air Temperature: required to manage summer and winter modes, to introduce compensation to the set temperature, and to perform energy recovery and economizer functions;
4. *U4 – Return Water Temperature: optionally required to maintain the minimum return temperature on the water from the heater (and as preheater) in winter mode, depending on the outside air temperature (lack of sensor means the function is not performed);*
5. *U5 – Discharge Air Pressure: optionally required to maintain the set pressure in the air supply duct by controlling the fan speed (lack of sensor means the function is not performed);*
6. *U6 – Return Air Pressure: optionally required to maintain the set pressure in the air supply duct by controlling the fan speed (lack of sensor means the function is not performed);*
7. U7 – Energy Recovery Exchanger differential Pressure Switch: absolutely required to protect the exchanger against frosting/icing - active state (close) exceeding the set pressure level disables the use of the exchanger - de-icing function; alternatively, in case of an air handling unit with mixing dampers:
    a. *U7 – Return CO2 Concentration: optionally required to ensure the appropriate share of fresh air while maintaining the set level of CO_2 concentration in the return air when using energy recovery mixing dampers - no connection does not perform the function;*
8. *U8 – Filters status: optionally required to monitor filter contamination, without implementing additional functions;*
9. I1 – Antifreeze Thermostat: absolutely required to protect the preheater against freezing - active (closed) state causes the preheater valve to open to 100% and turns on the preheater pump (always needed);
10. *I2 – (Pre)Heater Pump fault: optionally required, by default, to trigger an alarm condition (active state closed) reporting a (pre)heater failure, it can also be configured in PreHeater parameters as confirmation of the (pre)heater pump operation, which will report a (Pre)Heater Failure after a certain time if the (pre)heater pump is turned on and has not been confirmed operating;*

11. I3 – Fan Run or Fan Belt state: absolutely required to confirm the operation of ventilation as a state from inverters or a state of compression on fans (as control of belts on fans), lack of confirmation after a certain time causes an alarm condition (active open state) reporting a Fans Failure and stops the air handling unit (always needed);
12. I4 – Operation Switch: required to confirm the permission to operate the air handling unit, for service stop of the air handling unit (always needed);
13. A1 – (Pre)Heating Valve: control of the (pre)heating valve is calculated as a result depending on the temperature and humidity control (humidification does not allow heating) (always needed);
14. A2 – Cooling Valve: control of the cooling valve (if allows on the configuration) calculated as a result depending on the temperature and humidity control (as dehumidification);
15. A3 – Energy Recovery Control: control of the exchanger depending on the configuration - rotational speed, the opening of the bypass/mixing damper, or opening of the valve calculated as a result depending on the temperature and CO_2 control (mixing damper);
16. A5 – Discharge Fan Control: control of the fan speed on the discharge air duct with priority in relation to maintaining the set pressure in the discharge air duct. In the absence of a pressure sensor, it depends on temperature control, humidity control, CO_2 control, and manual setting;
17. A6 – Return Fan Control: control of the fan speed on the return air duct with priority in relation to maintaining the set pressure in the return air duct. In the absence of a pressure sensor, it depends on temperature control, humidity control, CO_2 control, and manual setting;
18. O1 – Dampers Command: command to open/close isolated dampers (outside and exhaust);
19. O2 – Fans Command: common command to start discharge & return fans (typical start command for inverter);
20. O3 – (Pre)Heater Pump Command: command for the switch on/off (pre)heating pump;
21. O4 – Energy Recovery Command: command depending on the configuration for the switch on/off wheel unit or twin-coil pump.

5.2 Extensions

Due to the wide range of AHU implementations, in addition to the base unit, the AAC20 controller, an extension module, iSMA-B-4U4A or -MIX18, can be added as necessary. The extension module must be equipped with the Modbus communication set, with address 1 and baud rate of 115200 kbps.

5.2.1 4U4A-H

Configuration

Configuration of the module's communication and inputs and outputs is carried out in the iSMA Configurator software.

The required communication settings are as follows:

- **Actual baud rate:** 115200 bps;

- MAC Address: 1;
- Protocol Type: Modbus RTU.

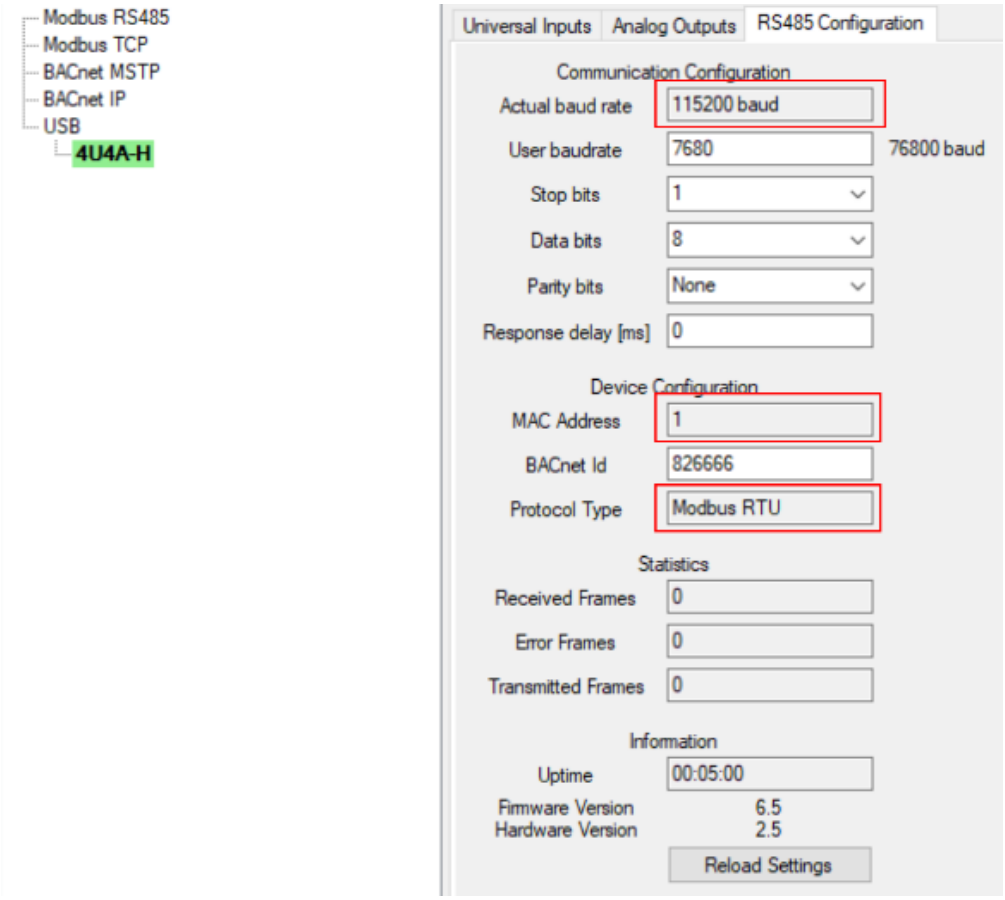


Figure 5. Modbus configuration of the iSMA-B-4U4A-H extension module

The required inputs settings are as follows:

- U1: disable resistance input;
- U2: disable resistance input;
- U3: resistance input;
- U4: 10K3A1 NTC B-3975K (°C).

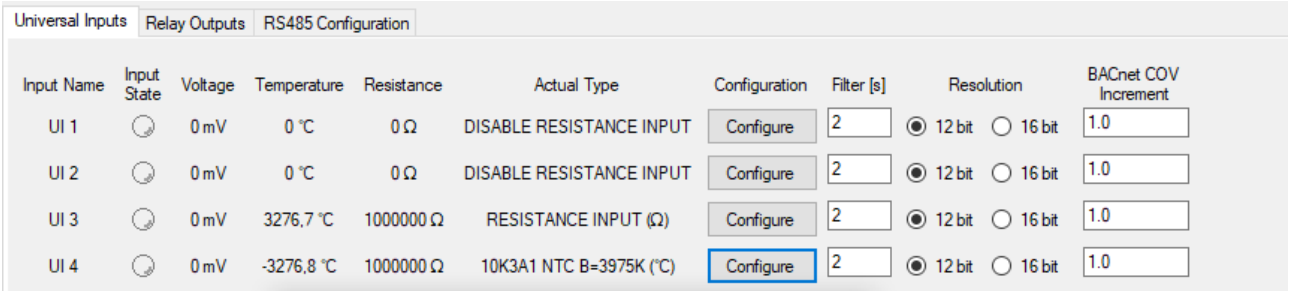


Figure 6. Inputs configuration of the iSMA-B-4U4A-H extension module in the iSMA Configurator

Outputs are required to be set as default.

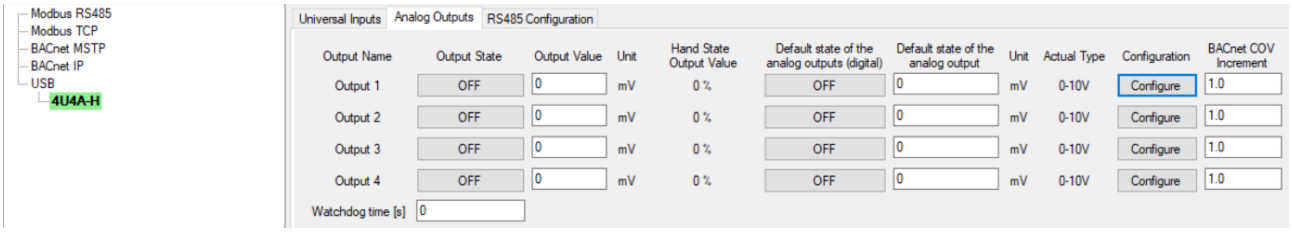


Figure 7. Configuration of analog outputs in the iSMA-B-4U4A-H module in the iSMA Configurator

Functional I/O Specification

The list below describes sensors and signals supported by the AHU application, indicating which of them are absolutely required, in what configurations, and those which are optional:

1. U1 – Discharge Air Humidity: required to perform the discharge air humidity control function - for supply-exhaust and supply air handling units;
2. U2 – Return Air Humidity: required to perform the discharge air humidity control based on the return air humidity - only for supply and exhaust air handling units;
3. *U3 – Humidifier fault: optionally required, by default, to trigger an alarm condition (active state closed) reporting a humidifier failure, it can also be configured in Humidifier parameters as confirmation of the humidifier operation, which will report a* ***Humidifier Failure*** *after a certain time if the humidifier is turned on and has not been confirmed operating. With the MINI version, it is also possible to connect a* ***Hygrostat*** *signal - in parallel or instead from a humidifier;*
4. *U4 – ReHeater Pump fault: optionally required, by default, to trigger an alarm condition (active state closed) reporting a reheater failure, it can also be configured in ReHeater parameters as confirmation of the reheater pump operation, which will report a* ***Reheater Failure*** *after a certain time if the reheater pump is turned on and has not been confirmed operating;*
5. A1 – Humidifier Control: control of the humidifier (if allows on the configuration) calculated as a result depending on humidity control;
6. A2 – Reheating Valve: control of the reheating valve (if allows on the configuration) calculated as a result depending on the temperature and humidity control (as dehumidifacation);
7. A3 – Humidifier Command: command for the switch on/off humidifier (depending on configuration - 1 water humidifier the switch on/off depending on the request, 2 - steam humidifier permanent switch on if AHU is running);
8. *A4 – ReHeater Pump Command: command for the switch on/off preheating pump.*

5.2.2 MIX18

Configuration

Configuration of the module's communication and inputs and outputs is carried out in the iSMA Configurator software.

The required communication settings are as follows:

- Actual baud rate: 115200 bps;
- MAC Address: 1;
- Protocol Type: Modbus RTU.

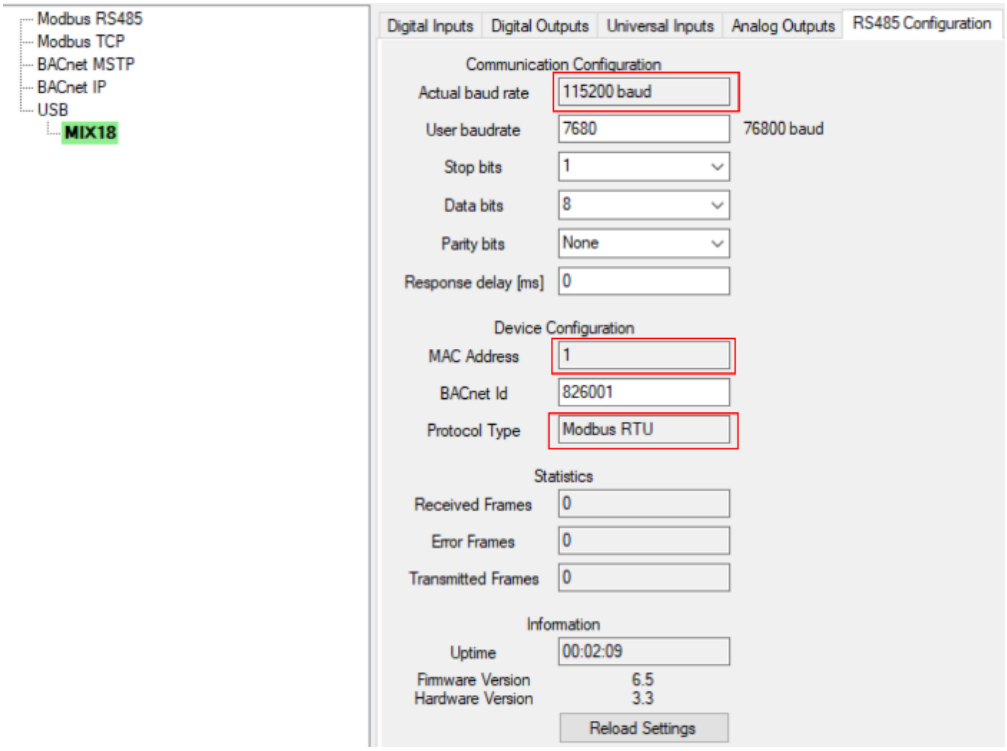


Figure 8. Modbus configuration of the iSMA-B-MIX18 extension module

The required inputs settings are as follows:

- **U1:** disable resistance input;
- **U2:** disable resistance input;
- **U3:** 10K3A1 NTC B-3975K (°C);
- **U4:** 10K3A1 NTC B-3975K (°C);
- **U5:** disable resistance input.

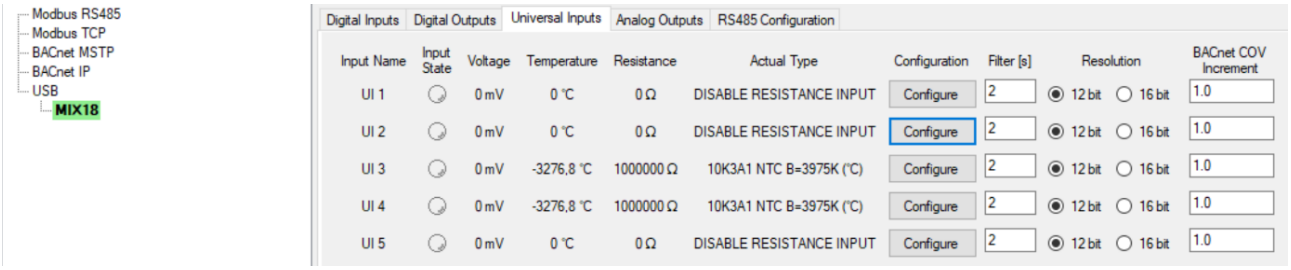


Figure 9. Inputs configuration of the iSMA-B-MIX18 extension module in the iSMA Configurator

Outputs, analog and digital in MIX18, are set as default. Analog outputs are presented below:

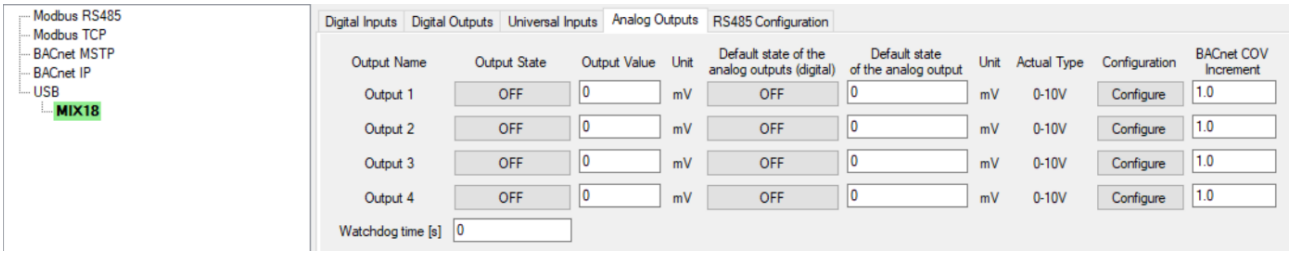


Figure 10. Configuration of analog outputs in the iSMA-B-MIX18 module in the iSMA Configurator

Functional I/O Specification

The list below describes sensors and signals supported by the AHU application, indicating which of them are absolutely required, in what configurations, and those which are optional:

1. U1 – Discharge Air Humidity: required to perform the discharge air humidity control function - for supply-exhaust and supply air handling units;
2. U2 – Return Air Humidity: required to perform the discharge air humidity control based on the return air humidity - only for supply and exhaust air handling units;
3. *U3 – Cooling Limit Temperature: optionally required to control the minimum temperature level behind the cooler in air dehumidification mode;*
4. *U4 – Mixing Temperature: optionally required to control the minimum temperature level behind the mixing damper depending on the Outside Air Temperature;*
    a. *U4 – Medium Temperature: optionally required to control the minimum level of medium temperature on the pipe of the twin-coil exchanger depending on the outside air temperature;*
    b. *U4 – Exhaust Air Temperature: optionally required to control the minimum temperature level behind the wheel and cross-flow exchanger depending on the outside air temperature;*
5. *U5 – Outside Air Humidity: optionally required to perform economizer function;*
6. *I1 – Humidifier fault: optionally required, by default, to trigger an alarm condition (active state closed) reporting a humidifier failure, it can also be configured in Humidifier parameters as confirmation of the humidifier operation, which will report a **Humidifier Failure** after a certain time if the humidifier is turned on and hasn't confirmed;*
7. *I2 – ReHeater Pump fault: optionally required, by default, to trigger an alarm condition (active state closed) reporting a reheater failure, it can also be configured in ReHeater parameters as confirmation of the reheater pump operation, which will report a **Reheater Failure** after a certain time if the reheater pump is turned on and hasn't confirmed;*
8. I3 – Hygrostat: required as protection against excessive humidification (flooding), exceeding the set humidity level (actively closed state) disables the humidification function;
9. *I4 – Energy Recovery fault: optionally required, by default, to trigger an alarm condition (active state closed) reporting an energy recovery unit or pump failure, it can also be configured in Exchanger parameters as confirmation of the energy recovery unit or pump operation, which will report an **Energy Recovery Failure** after a certain time if the energy recovery unit or pump is turned on and hasn't confirmed;*
10. I5 – Manual Reset: optionally required (for MIX18), allows after configuring (default use an auto resetting function) use for manual resetting of alarms;
11. A1 – Humidifier Control: control of the humidifier (if allows on the configuration) calculated as a result depending on humidity control;
12. A2 – Reheating Valve: control of the reheating valve (if allows on the configuration) calculated as a result depending on the temperature and humidity control (as dehumidification);
13. A3 – Humidifier Command: command for the switch on/off humidifier (depending on configuration - 1 water humidifier the switch on/off depending on the request, 2 - steam humidifier permanent switch on if ahu is running);
14. *A4 – ReHeater Pump Command: command for the switch on/off preheating pump;*
15. *O1 – Fans Failure Alarm: optionally required, collective alarm common for both fans to be used as LED signalling on the front of the control cabinet;*

16. *O2 – Heater Pumps Failure Alarm: optionally required, collective alarm common for both heater pumps to be used as LED signalling on the front of the control cabinet;*
17. *O3 – Energy Recovery Failure Alarm: optionally required, collective alarm for the energy recovery exchanger (depending on configuration) to be used as LED signalling on the front of the control cabinet;*
18. *O4 – Humidifier Failure Alarm: optionally required, collective alarm for the humidifier to be used as LED signalling on the front of the control cabinet.*

6 Configuration

Configuration of parameters based on the air handling unit model is available in three ways:

- from the AAC20's web server (recommended);
- from the AAC20's LCD;
- using the BACnet IP/Modbus TCP protocols (remotely/directly from the BMS system).

By default, the AHU application is not set to autologin to the web server. To log in to the AAC20 web server, insert the IP address of the AAC20 controller in the Internet browser's address bar and confirm with Enter.

Log in using the default admin credentials:

- login: service
- password: 2468

or log in using default end user (lower level of permissions than the service user - no possibility to change configuration, only setpoints) credentials;

- login: user
- password: 1357

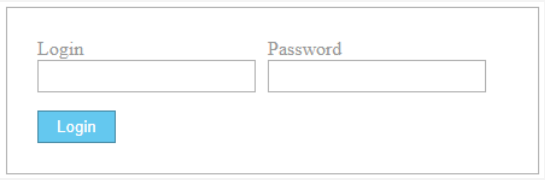


Figure 11. Login window

Remember to copy necessary web server files to the controller's SD card (files from the selected AHU application example\Generation Output Files folder folder) and flash memory (index.html) in order for the web server to work properly. More on using the AAC20 web server is available in the Visualization Web Server user manual.

To use the LCD display in the AAC20 controller, there are 6 dedicated keys:

- **Esc:** exit key;
- **Enter:** select, move the cursor to the right;
- **Arrow up:** add/subtract, menu navigation;
- **Arrow down:** add/subtract, menu navigation;
- **F1:** function key;
- **F2:** function key.

To log in to the AHU application in the AAC20 controller (to switch between users with different authorization levels) using the LCD display, follow these steps:

- long press the F2 key (displays a list of available users);
- use the arrow keys to select a user (in order to display the Config folder, select the lcd_admin user);
- approve by holding the Enter key (displays "Enter password";
- use the arrow keys (the change of the digital value by 1) and move through the coming fields (using the Enter key), enter the password to the application (the password is: 4321);
- long press the Enter key to confirm the password;
- cancelling the login process and exiting from the system menu – press and hold the Esc key.

More on using the AAC20 controller with an LCD display is available in the AAC20 LCD User Manual.

6.1 Configurable Parameters

This section lists all parameters available to configure according to the requirements of the installed air handling unit model:

1. **HeaterMode** allows the user to select a single heater or two heaters (where the second heater is mainly used for air dehumidification) and can be set to values:
    a. **Heater (select 1 on LCD)** for using as a single heater (without humidity control);

   b. **PreHeater & ReHeater (2 on LCD)** for using as preheater & reheater (for dehumidification function).
2. **EnergyRecovMode** allows the user to select the model of the exchanger that the air handling unit is equipped with (or to select operation without the exchanger if it does not exist in the air handling unit) and can be set to values:
   a. **None (0 on LCD)** for non-exchanger (AHU without exchanger);
   b. **Wheel (1 on LCD)** for wheel exchanger (AHU with wheel exchanger);
   c. **Cross Flow (2 on LCD)** for crossflow exchanger (AHU with cross-flow exchanger);
   d. **Mixing Dampers (3 on LCD)** for mixing dampers (AHU with mixing dampers which works as exchanger);
   e. **Twin Coil & Return Pump (4 on LCD)** for twincoil with pump on return pipe (AHU with twin-coil exchanger with pump on return pipe);
   f. **Twin Coil & Supply Pump (5 on LCD)** for twincoil with pump on discharge pipe (AHU with twin-coil exchanger with pump on discharge pipe.
3. **CoolerMode** allows the user to choose the model with or without water cooler (cooling coil with valve and modulating actuator) and can be set to values:
   a. **None (0 on LCD)** for non-cooler;
   b. **Cooler (1 on LCD)** for cooler.
4. **HumidifierMode** allows the user to choose a model with or without the humidifier required to maintain the humidity (selectable steam or water) an can be set to values:
   a. **None (0 on LCD)** for non-humidifier;
   b. **Water Humidifier (1 on LCD)** for water humidifier (control and the water pump works when humidification is needed);
   c. **Steam Humidifier (2 on LCD)** for steam humidifier (permanent start command for humidifier to work while the AHU is running, control works when humidification is needed).
5. **EconomizerMode** allows the user to use the economizer function for models equipped with an exchanger - thermal energy recovery system (heat and cold) and can be set to values:
   a. **None (0 on LCD)** for the non-economizer function (for AHU without exchanger or no need for economizer function - not recommended);
   b. **Eco Return Temp (1 on LCD)** for economizer function based on return temperature (standard for AHU with exchanger);
   c. **Eco Enthalpy (2 on LCD)** for economizer function based on enthalpy (for AHU with exchanger and humidification function - required outside humidity sensor extra).
6. **TempCtrlMode** allows the user to select the temperature control method as required and can be set to values:
   a. **Cascade Temp (1 on LCD)** for cascade temperature control (discharge air temperature control in relation to room (return) air temperature control excluding comfort zone - only for discharge and return AHU systems);
   b. **Constant Disch Temp (2 on LCD)** for constant discharge temperature control (control of the constant discharge air temperature without the influence of the room (return) air temperature;
   c. **Comfort Zone Temp (3 on LCD)** for comfort zone temperature control (discharge air temperature control in relation to room (return) air temperature control including comfort zone - only for discharge and return AHU systems).
7. **HumCtrlMode** allows the user to select the humidity control method as required and can be set to values:

   a. **Comfort Hum (1 on LCD)** for comfort humidity control (room (return) air humidity control including comfort zone - only for discharge and return AHU systems);
   b. **Return Hum (2 on LCD)** for return humidity control (room (return) air humidity control excluding comfort zone - only for discharge and return AHU systems);
   c. **Disch Abs Hum (3 on LCD)** for discharge absolute humidity control (cascade discharge air humidity control in relation to room (return) air humidity control excluding comfort zone - only for discharge and return AHU systems);
   d. **Constant Disch Abs Hum (4 on LCD)** for constant discharge absolute humidity control (control of the constant discharge air absolute humidity without the influence of the room (return) air humidity.
8. **PlantMode** can be set to the values, which are used in the **Plant Schedule** as event according to the desired operating mode of AHU (read-only in LCD and web server or BACnetIP/Modbus TCP as a variable):
   a. **Off (0 on LCD)** for switching the unit off (means stop AHU);
   b. **Night Cycle (2 on LCD)** for night operation with reduced parameters to save energy;
   c. **Occupied Period (4 on LCD)** for normal operation allowing to obtain air comfort parameters for the user.

Note: Other values for the PlantMode are dedicated for future use.

Note: The same values can be used not only on the AAC20 LCD display, but also via Modbus registers/BACnet objects.

6.2 Web Server

By default, the AHU application is not set to autologin to the web server. To log in to the AAC20 web server, insert the IP address of the AAC20 controller in the Internet browser's address bar and confirm with Enter.

Log in using the default admin credentials:

- login: service
- password: 2468

or log in using default end user (lower level of permissions than the service user - no possibility to change configuration, only setpoints) credentials;

- login: user
- password: 1357

Figure 12. Login window

Remember to copy necessary web server files to the controller's SD card (files from the selected AHU application example\Generation Output Files folder folder) and flash memory (index.html) in order for the web server to work properly. More on using the AAC20 web server is available in the Visualization Web Server user manual.

From the downloaded and extracted archive, copy all files the selected AHU application example\Generation Output Files folder, directly to main level tree of the SD card (do not create folders or subfolders to locate the files there).

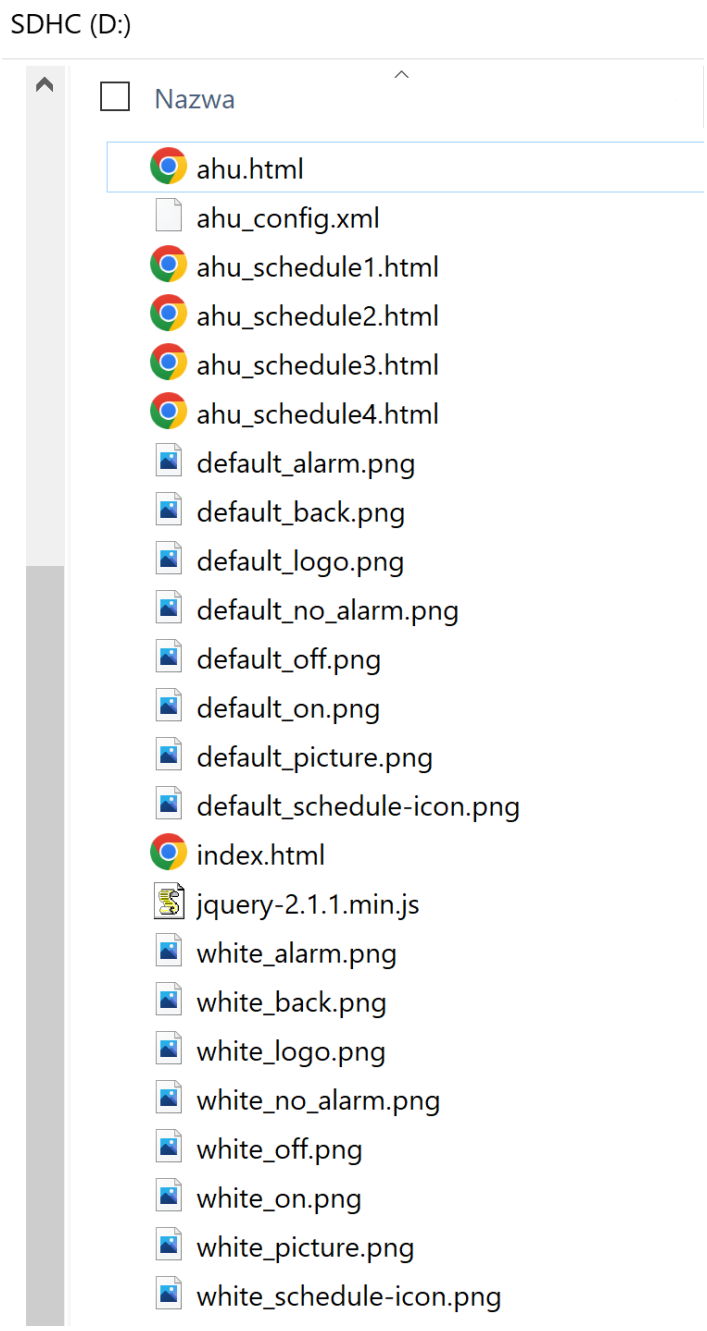


Figure 13. Files to copy from the selected AHU application example/Generation Output Files folder

It is also required to upload the index.html file from the web server folder of the archive to the AAC20 flash memory using the AAC20 Updater. In order to upload the index.html file, make sure that the Modbus TCP communication is active and type a correct IP address and port number if different than the default. To choose the index.html file, click the Select File button, and then send it to the device with the Send File button.

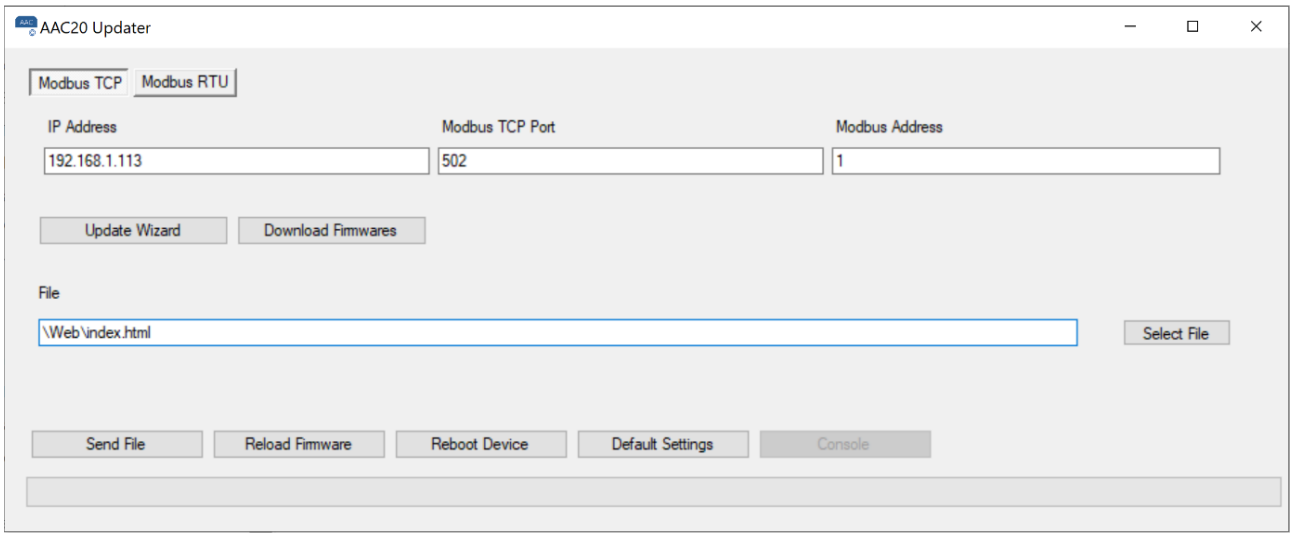


Figure 14. AAC20 Updater

More information on how to run the web server can be found in the AAC20 Visualization Web Server user manual.

Now, the application is ready for configuration.

Typically, the web configuration is intended for integrators, enabling to configure the application for a specific model of the air handling unit.

For the user's convenience, as well as to limit an access to configuration parameters, ready-made website templates have been prepared for the sample applications of air handling units described in the next chapter.

Ready templates are archived and placed in the main folder with files for the web server (Visualization web server files) described as ahu1.zip to ahu8.zip, where the numbering is consistent with the described examples.

In addition, separate configuration files have been prepared in order to be able to change names or translate to a language other than English. As in the case of the web file archive, the configuration files have the same numbering from Visualization_configurator_ahu1.xlsm to Visualization_configurator_ahu8.xlsm. Appropriate synoptic graphics were also prepared with the same numbering from picture1.png to picture8.png.

The web server for the AHU application is based on the default AAC20 web server configuration. In the web server, it is possible to configure the AHU application for a selected model of ventilation system, but also to set setpoints values, and monitor input and output signals along with alarm states.

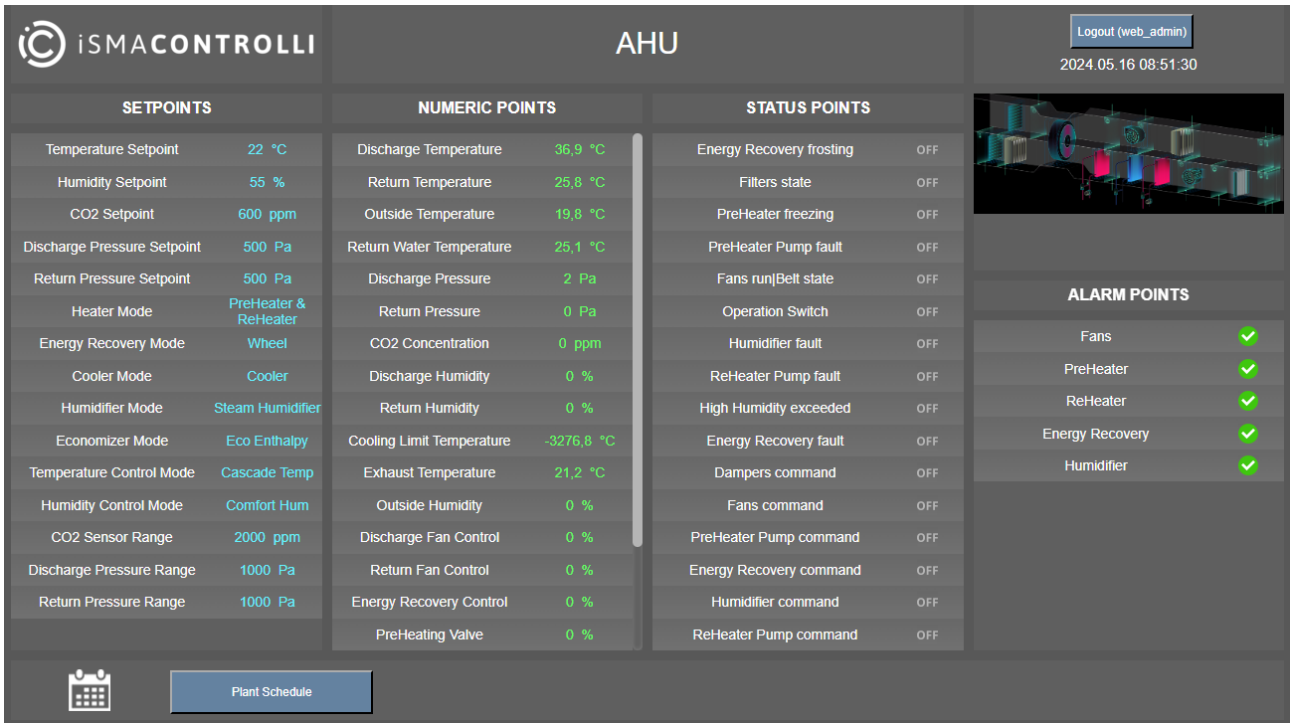


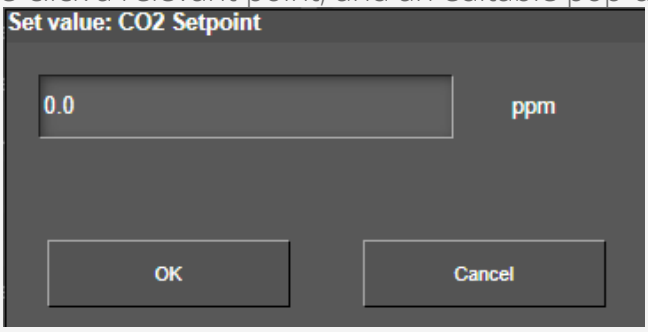
Figure 15. The web server for the AHU application example no. 5 - intergrator view (admin login)

Identically like in the default web server, the screen is divided into 4 columns as presented above:

- Setpoints (the only column including editable points);
- Numeric Points (read-only);
- Status Points (read-only);
- Alarm Points (read-only).

6.2.1 Setpoints

In order to edit elements available in this column, and therefore configure parameters available here, double-click a relevant point, and an editable pop-up window appears:



The Setpoints column, starting from the top, contains first the setpoints for:

- temperature;
- humidity;
- CO_2;
- discharge pressure;
- return pressure.

Then, relevant configuration points are available:

- heater mode;
- energy recovery mode;
- cooler mode;
- humidifier mode;
- economizer mode;
- temperature control mode;
- humidity control mode.

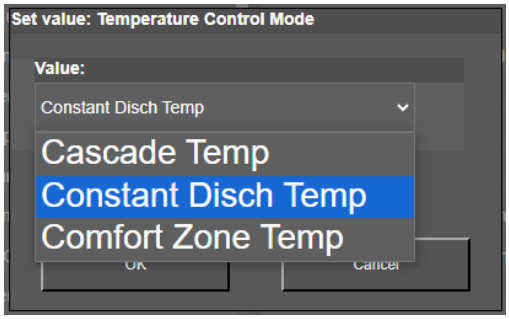


Figure 16. Values available for the temperature control mode

Note: Settings of the above modes are described in detail in the next section.

At the end of the list in the Setpoint column, there are points for configuration of ranges for voltage sensors such as:

- CO_2;
- discharge pressure;
- return pressure.

It has been assumed that the humidity sensors are also of voltage type in range of 0-100% for 0-10 V DC, by default.

Recommended setpoint vaules

Recommended setpoints range for the AHU application to function properly:

1. **Temperature setpoint:** 13°C-30°C
2. **Humidity setpoint:** 30% RH-70% RH
3. **CO_2 setpoint:** 300 ppm-1500 ppm
4. **Discharge pressure setpoint:** 0 Pa-10000 Pa
5. **Return pressure setpoint:** 0 Pa-10000 Pa

6.2.2 Numeric Points

The Numeric Points column contains all numerical inputs and outputs, divided first into inputs and then into outputs. It includes inputs and outputs for the AAC20 controller with the MINI/MIX extension modules.

In the column, all monitored inputs are listed (here along with an annotation of the source device, AAC20 controller or extension I/O module):

- Discharge Temperature [AAC20];
- Return Temperature [AAC20];
- Outside Temperature [AAC20];
- Return Water Temperature [AAC20];
- Discharge Pressure [AAC20];

- Return Pressure [AAC20];
- CO2 Concentration [AAC20];
- Discharge Humidity [4U4A-H, MIX18];
- Return Humidity [4U4A-H, MIX18];
- Cooling Limit Temperature [MIX18];
- Exhaust, Mixing or Medium Temperature [MIX18];
- Outside Humidity [MIX18].

Then, a list of monitored outputs (here along with an annotation of the source device):

- Discharge Fan Control [AAC20];
- Return Fan Control [AAC20];
- Energy Recovery Control [AAC20];
- PreHeating Valve [AAC20];
- Cooling Valve [AAC20];
- ReHeating Valve [4U4A-H, MIX18];
- Humidifier Control [4U4A-H, MIX18].

Lastly, the list is concluded with an information point about the operating mode of the ventilation system:

- Plant Mode.

6.2.3 Status Points

The Status Points column contains all digital inputs and outputs, divided first into inputs and then into outputs. It includes inputs and outputs for the AAC20 controller with the MINI/MIX extension modules.

In the column, all monitored inputs are listed (here along with an annotation of the source device, AAC20 controller or extension I/O module):

- Energy Recovery frosting [AAC20];
- Filters state [AAC20];
- PreHeater freezing [AAC20];
- PreHeater Pump fault [AAC20];
- Fans run or Fan Belt state [AAC20];
- Operation Switch [AAC20];
- Humidifier fault [4U4A-H, MIX18];
- ReHeater Pump fault [4U4A-H, MIX18];
- High Humidity exceeded (hygrostat) [MIX18];
- Energy Recovery fault [MIX18].

Then, a list of monitored outputs (here along with an annotation of the source device, AAC20 controller or extension I/O module):

- Dampers command [AAC20];
- Fans command [AAC20];
- PreHeater Pump command [AAC20];
- Energy Recovery command [AAC20];
- Humidifier command [4U4A-H, MIX18];
- ReHeater Pump command [4U4A-H, MIX18].

6.2.4 Alarm Points

The last column informs about alarm states (displayed collectively) that might occur in devices controlled by the AHU application. The list of collective alarms is presented below (here along with an annotation of the source device, AAC20 controller or extension I/O module):

- Fans [MIX18];
- PreHeater [MIX18] (same output as for reheater);
- ReHeater [MIX18] (same output as for preheater);
- Energy Recovery [MIX18];
- Humidifier [MIX18].

6.2.5 Plant Schedule

In addition, the application supports a schedule that allows to control various operating plant modes as events of the ventilation system in time. The available operating plant modes are described later in this manual. Access to the schedule is the same as the default web server, using the Plant Schedule 1 button. Setting of hours and events is the same as in the default web server. The below example shows a configured schedule.

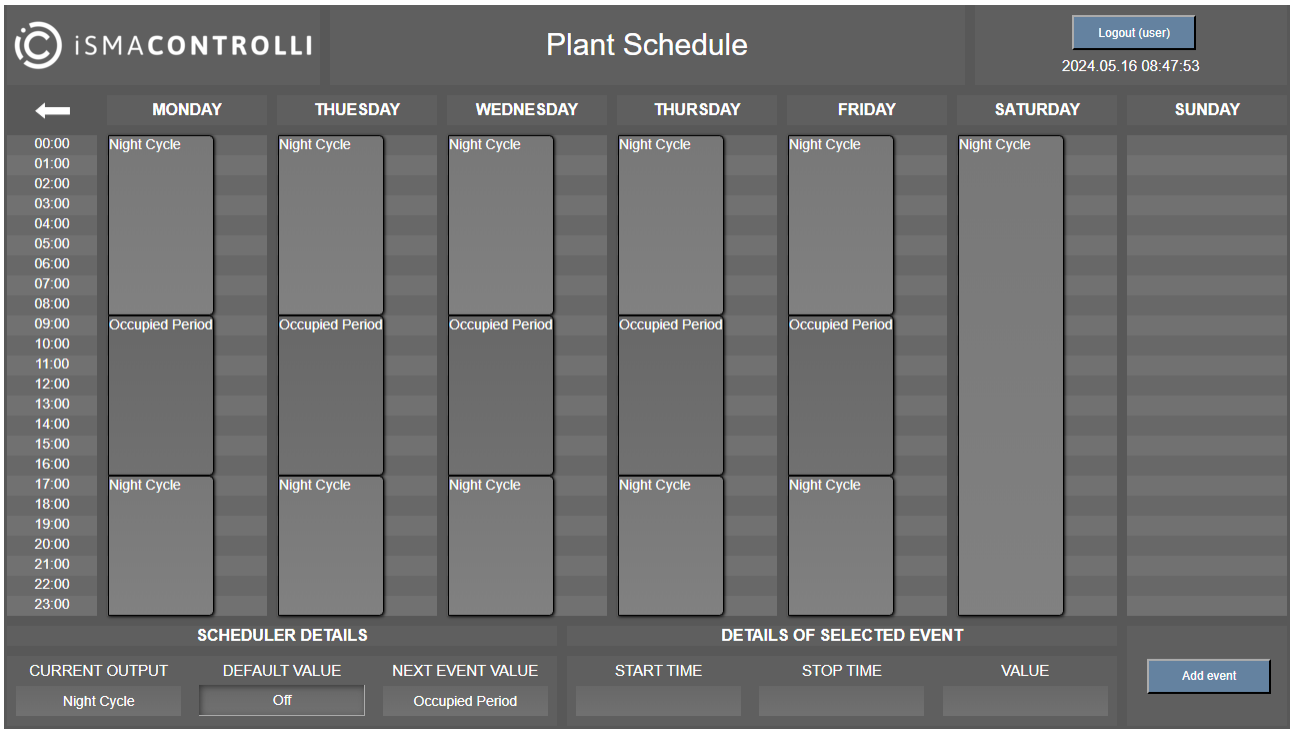


Figure 17. Schedule in the web server

6.2.6 User View

The below example is dedicated for application no. 5 in version for the end user, which has access to setpoints, but it is not possible to change the configuration from the web server level.

It also can read inputs, outputs of the controller (along with the module, depending on the configuration) and a graphical thumbnail of the air handling unit that the application supports.

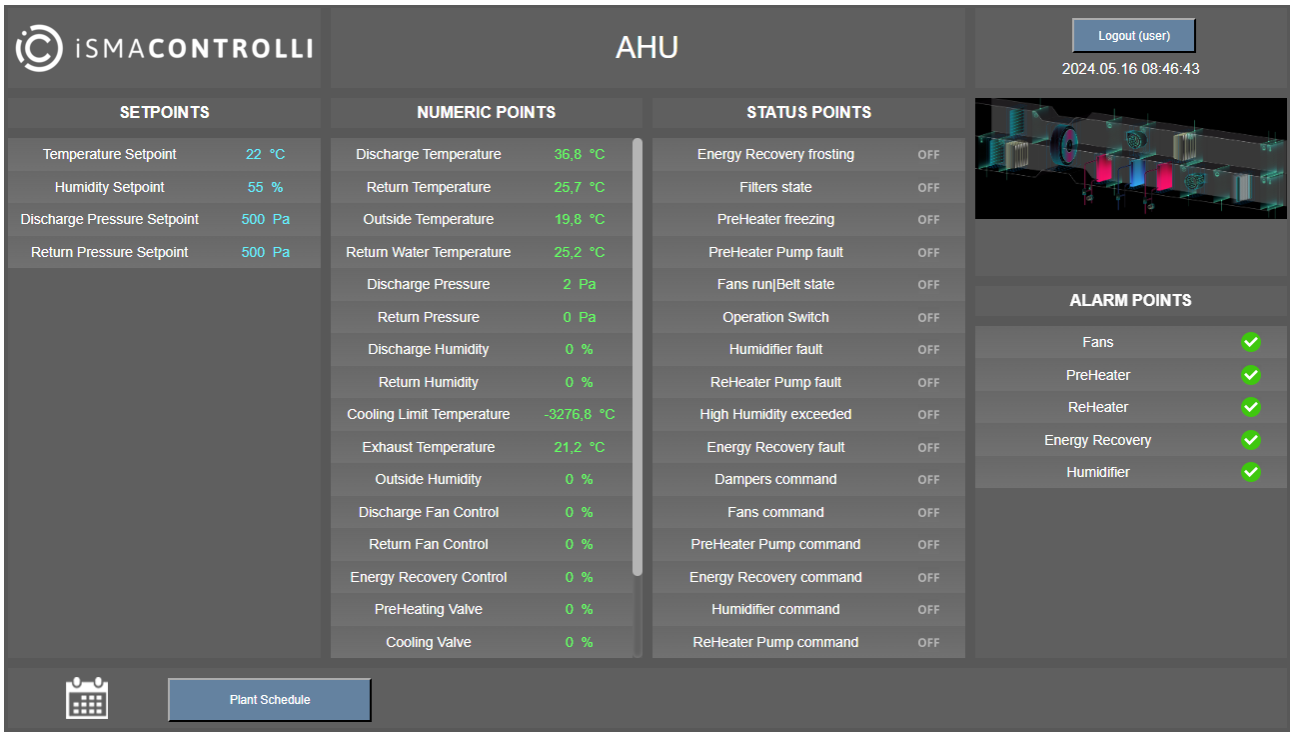


Figure 18. The web server for the AHU application example no. 5 - user view (user login)

6.3 LCD

To use the LCD display in the AAC20 controller, there are 6 dedicated keys:

- **Esc:** exit key;
- **Enter:** select, move the cursor to the right;
- **Arrow up:** add/subtract, menu navigation;
- **Arrow down:** add/subtract, menu navigation;
- **F1:** function key;
- **F2:** function key.

To log in to the AHU application in the AAC20 controller (to switch between users with different authorization levels) using the LCD display, follow these steps:

- long press the F2 key (displays a list of available users);
- use the arrow keys to select a user (in order to display the Config folder, select the lcd_admin user);
- approve by holding the Enter key (displays "Enter password";
- use the arrow keys (the change of the digital value by 1) and move through the coming fields (using the Enter key), enter the password to the application (the password is: 4321);
- long press the Enter key to confirm the password;
- cancelling the login process and exiting from the system menu – press and hold the Esc key.

More on using the AAC20 controller with an LCD display is available in the AAC20 LCD User Manual.

Apart from supporting the AHU application in the web server, it is also possible to configure it using the LCD display. The LCD display for the AHU application has been categorized in 5 folders:

- Inputs (numeric and digital);
- Outputs (numeric and digital);
- Setpoints;
- Config (visible only for the user with appropriate permissions);
- Schedule.

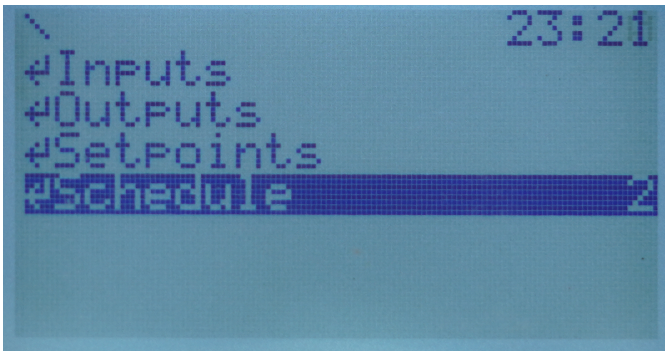


Figure 19. Folders on LCD

Access to the Inputs, Outputs, Setpoints, and Schedule folders does not require any authorization (the LCD service automatically uses the privileges of the default user - lcd).

6.3.1 Inputs

In the Inputs folder, the listed inputs are grouped first numerically, then digitally. To move to next screens/variables, use the up/down arrow buttons.

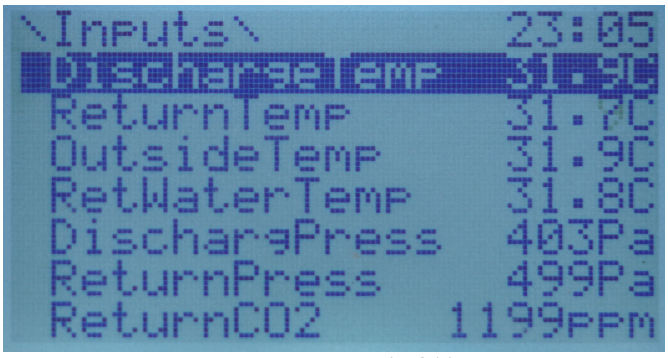


Figure 20. Inputs in the folder

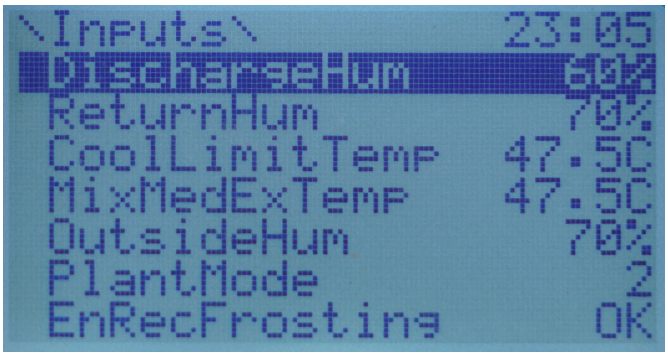


Figure 21. Inputs in the folder

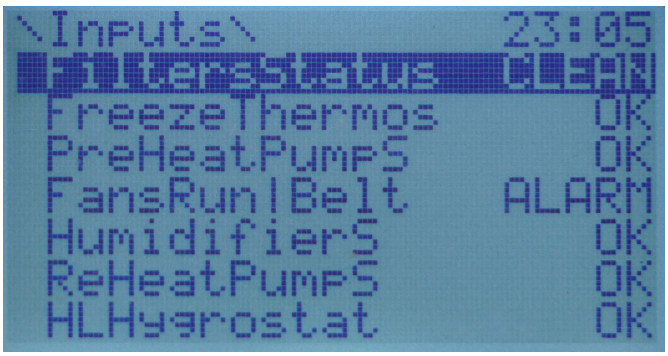


Figure 22. Inputs in the folder

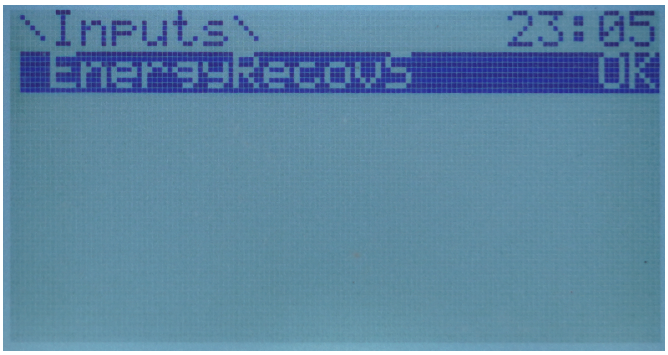


Figure 23. Inputs in the folder

The list of numeric inputs (here with an annotation of the source device, AAC20 controller or extension I/O module):

- **DischargTemp:** discharge temperature [AAC20];
- **ReturnTemp:** return temperature [AAC20];
- **OutsideTemp:** outside temperature [AAC20];
- **RetWaterTemp:** return water temperature [AAC20];
- **DischargPress:** discharge pressure [AAC20];
- **ReturnPress:** return pressure [AAC20];
- **ReturnCO2:** return CO_2 concentration [AAC20];
- **DischargeHum:** discharge humidity [4U4A-H or MIX18];
- **ReturnHum:** return humidity [4U4A-H or MIX18];
- **CoolLimitTemp:** cooling limit temperature [MIX18];
- **ExMedMixTemp:** exhaust or medium, or mixing temperature (depending on configuration using) [MIX18];
- **OutsideHum:** outside humidity [MIX18].

In addition, there is a variable informing about the operating mode of the ventilation system:

- **PlantMode:** plant mode [virtual variable].

Following, the digital inputs are listed (here with an annotation of the source device, AAC20 controller or extension I/O module):

- **EnRecFrostion:** energy recovery frosting status [AAC20];
- **FiltersStatus:** filters status [AAC20];
- **FreezeThermos:** freeze thermostat status [AAC20];
- **PreHeatPumpS:** preheating pump status [AAC20];
- **FansRun|Belt:** fans run or fans belt status [AAC20];
- **HumidifierS:** humidifier status [4U4A-H or MIX18];
- **ReHeatPumpS:** reheating pump status [4U4A-H or MIX18];
- **HLHygrostat:** high limit hygrostat status [MIX18];
- **EnergyRecovS:** energy recovery status [MIX18].

6.3.2 Outputs

Similarly to the Inputs folder, outputs have also been arranged in the following order - first the numeric outputs, then the digital ones.

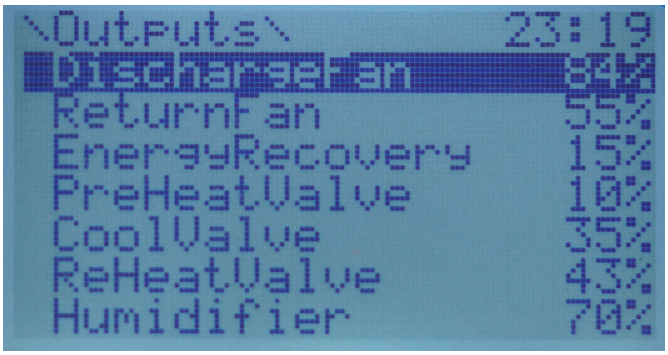


Figure 24. Outputs in the folder

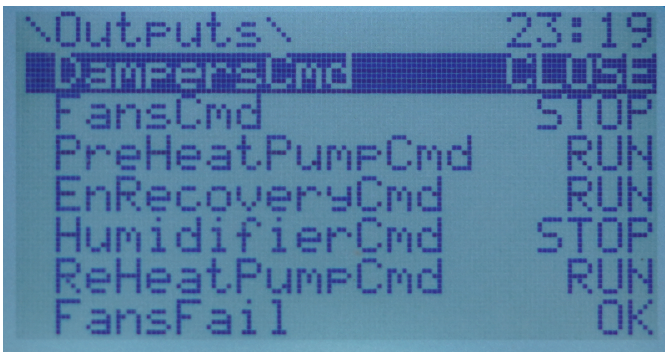


Figure 25. Outputs in the folder

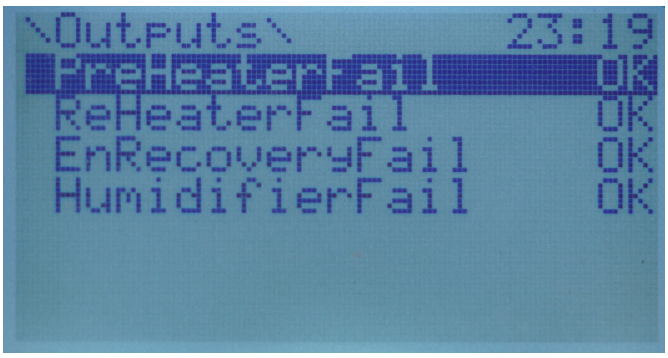


Figure 26. Outputs in the folder

The list of numeric outputs (here with an annotation of the source device, AAC20 controller or extension I/O module):

- **DischargeFan:** discharge fan control [AAC20];
- **ReturnFan:** return fan control [AAC20];
- **EnergyRecovery:** energy recovery control [AAC20];
- **PreHeatValve:** preheating Valve Control [AAC20];
- **CoolValve:** cooling valve control [AAC20];
- **ReHeatValve:** reheating valve control [4U4A-H or MIX18];
- **Humidifier:** humidifier control [4U4A-H or MIX18].

Following, the digital outputs are listed (here with an annotation of the source device, AAC20 controller or extension I/O module):

- **DampersCmd:** dampers command [AAC20];
- **FansCmd:** fans command [AAC20];
- **PreHeatPumpCmd:** preheater pump command [AAC20];
- **EnRecoveryCmd:** energy recovery command [AAC20];
- **HumidifierCmd:** humidifier command [4U4A-H or MIX18];
- **ReHeatPumpCmd:** reheater pump command [4U4A-H or MIX18];

- **FansFail:** fans failure alarm [MIX18];
- **PreHeaterFail:** preheater failure alarm [MIX18];
- **ReHeaterFail:** reheater failure alarm [MIX18];
- **EnRecoveryFail:** energy recovery failure alarm [MIX18];
- **HumidifierFail:** humidifier failure alarm [MIX18].

6.3.3 Setpoints

Next, it is the Setpoints folder containing settings intended for the end user.

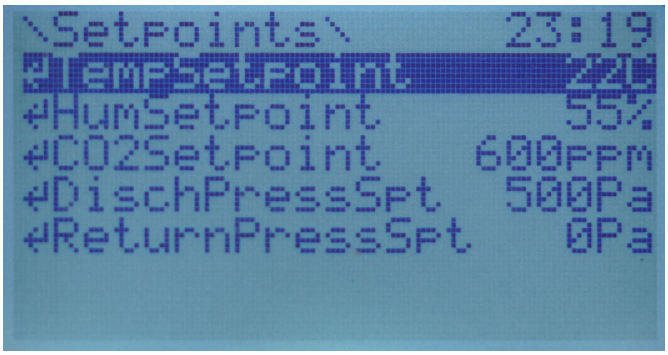


Figure 27. Points in the Setpoints folder

In the Setpoints folder, there are basic settings of the ventilation system, as listed below:

- **TempSetpoint:** temperature setpoint;
- **HumSetpoint:** humidity setpoint;
- **CO2Setpoint:** CO_2 concentration setpoint;
- **DischPressSpt:** discharge pressure setpoint;
- **ReturnPressSpt:** return pressure setpoint.

6.3.4 Config

For the Config folder to be visible and available on LCD display, log in from the LCD panel level (as described in the beginning of this section) with the user with appropriate permissions.

From the list of users, select the **lcd_admin** user (available: admin, lcd, lcd_admin). The default login password is **4321**, which can be changed as needed by logging into AAC20 using iC Tool.

After correct logging in, go to the Config folder and the configuration parameters contained therein.

In the Config folder, there are configuration parameters of the AHU application that allow it to be configured as required by a given ventilation system.

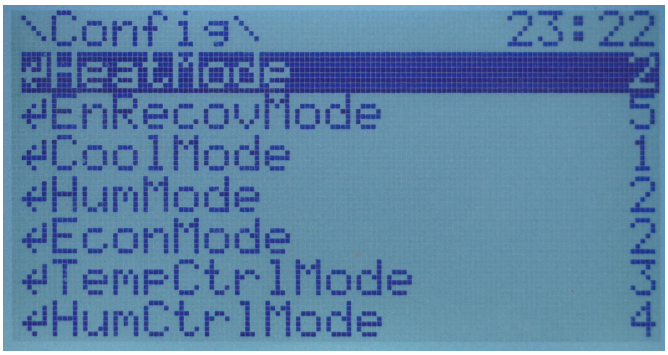


Figure 28. Points in the Config folder

The available configuration parameters are as follows:

- **HeatMode:** heater mode;
- **EnRecovMode:** energy recovery mode;
- **CoolMode:** cooler mode;
- **HumMode:** humidifier mode;
- **EconMode:** economizer mode;
- **TempCtrlMode:** temperature control mode;
- **HumCtrlMode:** humidity control mode.

Note: Settings of the above modes are described in detail in the Configurable Parametrs section.

On the next screen, it is possible to set ranges for voltage signals such as pressure or CO_2 sensors.

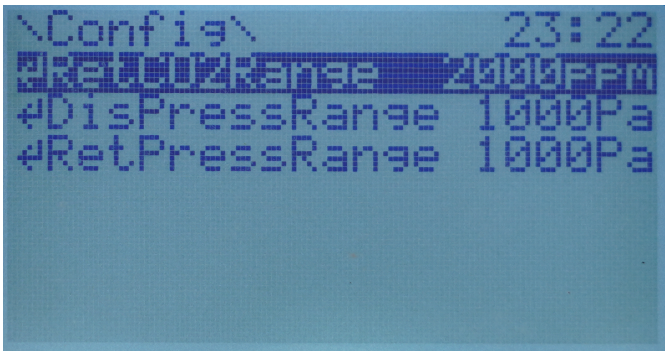


Figure 29. Points in the Config folder

- **RetCO2Range:** return CO_2 sensor range;
- **DisPressRange:** discharge pressure sensor range;
- **RetPressRange:** return pressure sensor range.

6.3.5 Schedule

The last component on the list (which is not a typical folder) is Schedule, which allows the user to program the operation modes in time as needed, individually for each day of the week. The scheduling support is described in the AAC20 LCD User Manual.

Sample schedule screenshots:

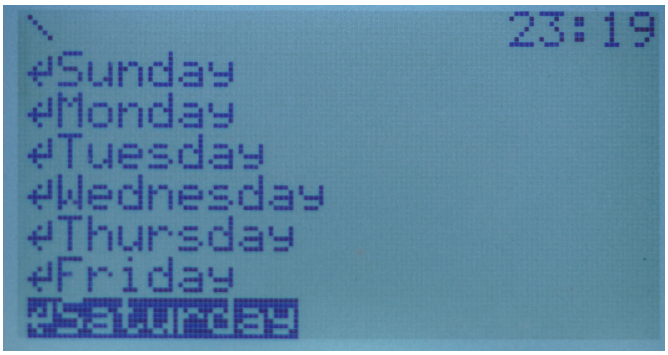


Figure 30. Contents of the Schedule folder

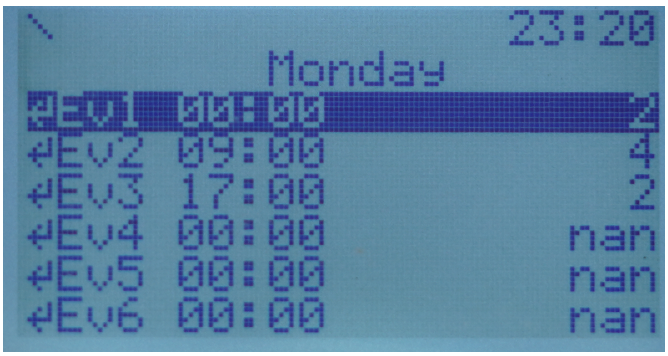


Figure 31. Contents of the Schedule folder

Note: Presently, setting a schedule is recommended in the web server. From LCD, it is now possible to check the schedule's settings. It is not possible to set the schedule from both locations simultaneously. To set the schedule from the LCD, it is required to switch off the web schedule using the iC Tool (change the Enable slot in the Schedule component under the ModbusTcpSlaveNetwork).

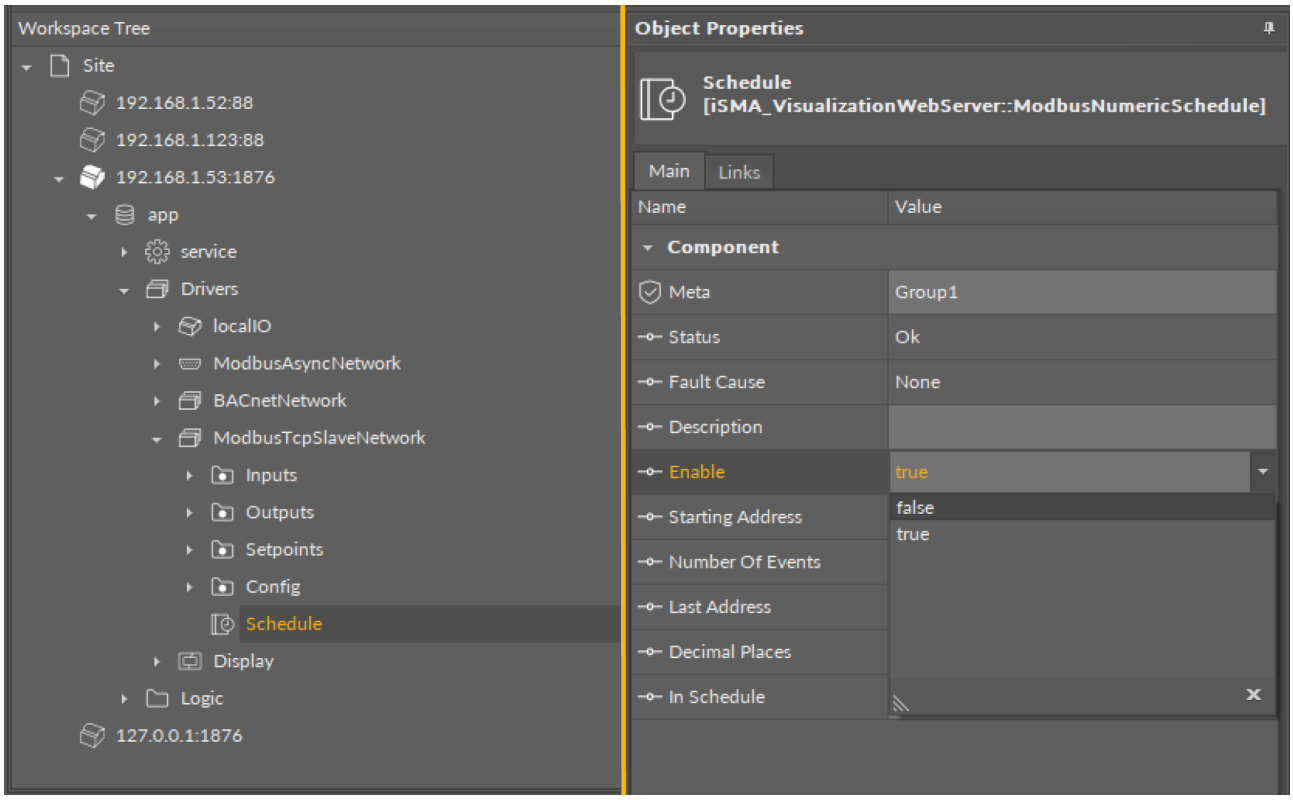


Figure 32. Switching off the web schedule

7 Modules of AHU Application

7.1 Functional Description of the Modules

This section contains descriptions of the functions performed by the individual modules of the AHU application. The descriptions include the use of the advanced parameters listed in the previous chapter. Descriptions of the functions will allow the user to understand the operation of a given module and will allow the user to make correct changes in advanced parameters.

7.1.1 Dampers

The Dampers module provides modulating control of the outside air, mixing air, and exhaust air dampers (formal for mixing air control) as dictated by a 0-100% damper control signal from the control module. Alternatively, if an optional mixed air temperature sensor is installed, a mixed air temperature control can be selected, either with a fixed mixed air temperature setpoint or with outside air temperature compensation. Air quality (CO2) override control to maximum fresh air can be implemented optionally.

The module has internal inputs for;

- the damper enable signal (DME);
- the damper control signal (DMS);
- mixed air temperature (MAT);
- and air quality (CO_2).

The internal outputs are a mixing air damper (MAD) and fan enable signal (FNE).

Delayed Fan Enable Output

To prevent freeze-up problems at start-up, this module interacts with the modules for heating coil and fans.

On receipt of the damper enable signal (DME) from the heating coil, the fan enable output (FNE) switches on, provided that the return damper is open and sent to the fan module. At start-up, the air handling unit will always start with recirculation for model with mixing dampers. In this case, the FNE output will be enabled directly after the DME input becomes true.

Ramped Operation of Dampers

The output to the dampers increases linearly to match the damper control signal (DMS). The ramping time is adjustable by the parameter DMS_RampTime and only occurs when the signal starts from the 0% position. Ramping takes place between the 0% and 100% control output signal.

Damper Control with Minimum and Maximum Damper Positioning

The module can work in several configurations. In a typical sequencing application, the module receives a damper control signal (DMS) from the control module. If the value of DMS is -1 the dampers are closed and forced recirculation is dictated from the control module. The DMS can be selected, defined by parameter DMS_RatioEnable, to be either as a position signal Y, or as a correction signal X, both with a possible range of 0-100%.

In the case of a Y signal, the input is directly transferred to the output MAD, after applying minimum and maximum limits, defined by parameters DMS_MinPosition and DMS_MaxPosition, as shown in the next figure.

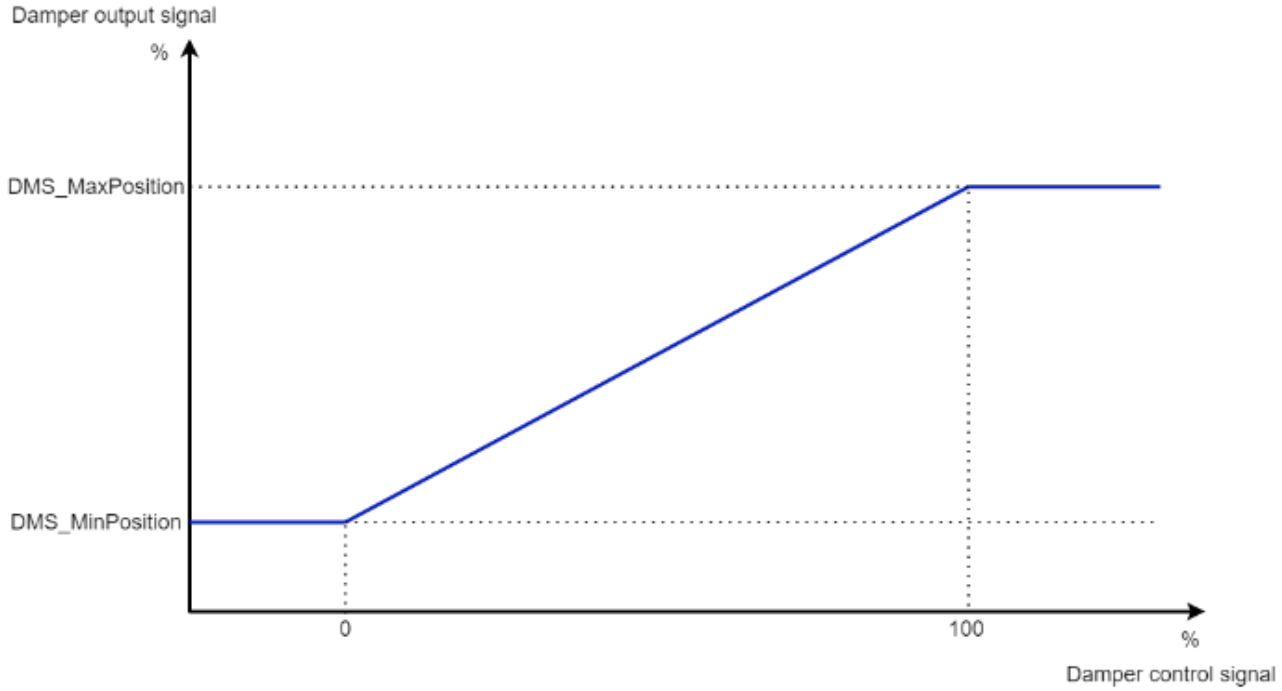


Figure 33. Damper output signal

In the case of the X signal, the output varies between the minimum and maximum limits, defined by parameters DMS_MinPosition and DMS_MaxPosition, over a sub-range of the X signal, determined by a ratio sequence with start and stop points, defined by parameters DMS_StartRatioControl and DMS_StopRatioControl, as shown in the next figure.

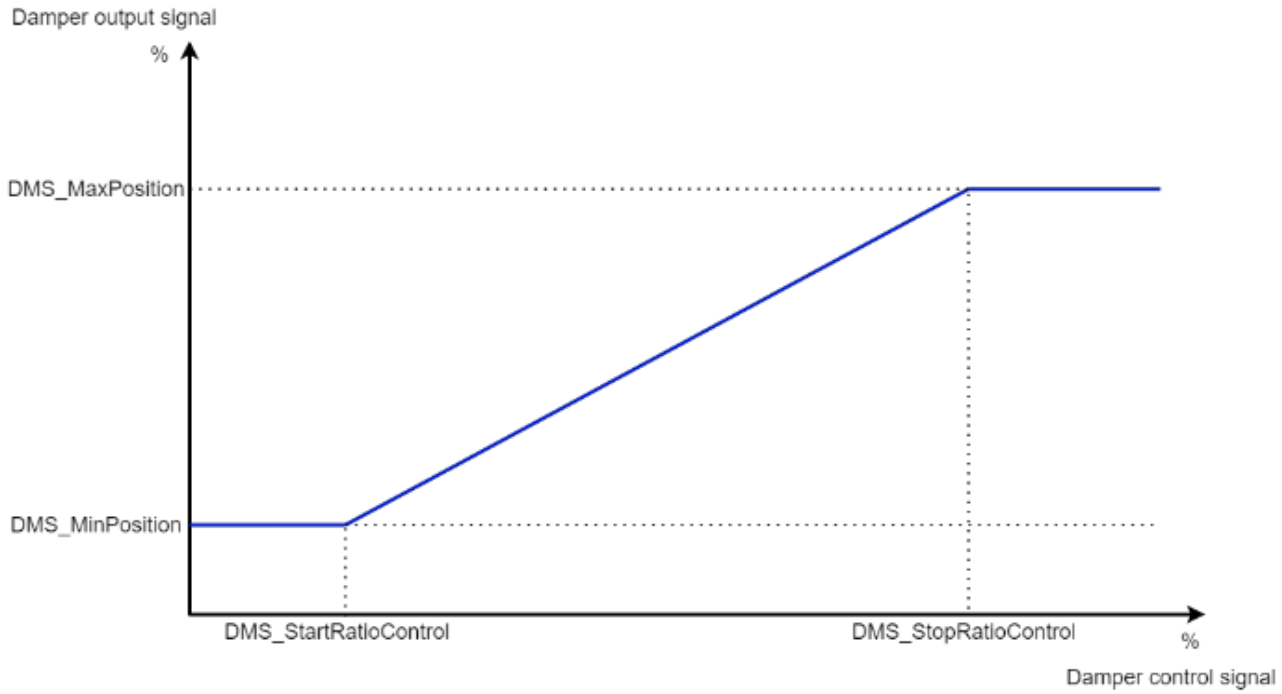


Figure 34. Damper output signal with correction

Mixed Air Temperature Setpoint with Outside Air Temperature Compensation

The mixed air temperature setpoint is compensated by the outside air temperature between the values defined by parameters OAT_MinSetpoint and OAT_MaxSetpoint and limited between the minimum and maximum setpoint values, defined by parameters MAT_MinSetpoint and MAT_MaxSetpoint, as shown in the next figure.

Note: If the parameter values of MAT_MinSetpoint and MAT_MaxSetpoint are equal, then compensation does not occur.

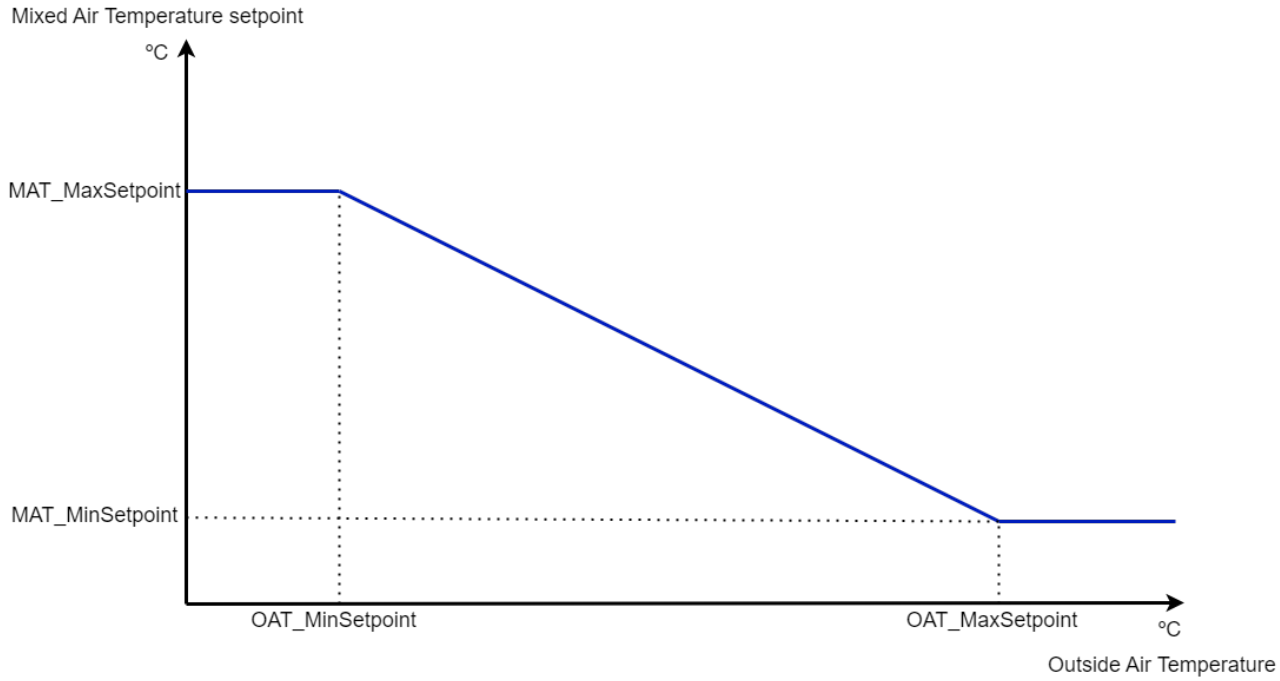


Figure 35. Mixed air temperature setpoint according to the outside air temperature

If no mixed air temperature sensor is available the dampers modulate only according to the damper control signal (DMS) from the control module, within minimum and maximum damper positions, defined by parameters DMS_MinPosition and DMS_MaxPosition.

Note: To render this operation inactive, set the maximum and the minimum outside air temperature (parameters OAT_MaxSetpoint and OAT_MinSetpoint) both to a value of -50°C (value lower then real outside air temperature).

In this case, the maximum fresh air damper position varies according to the outside air temperature as shown in the next figure.

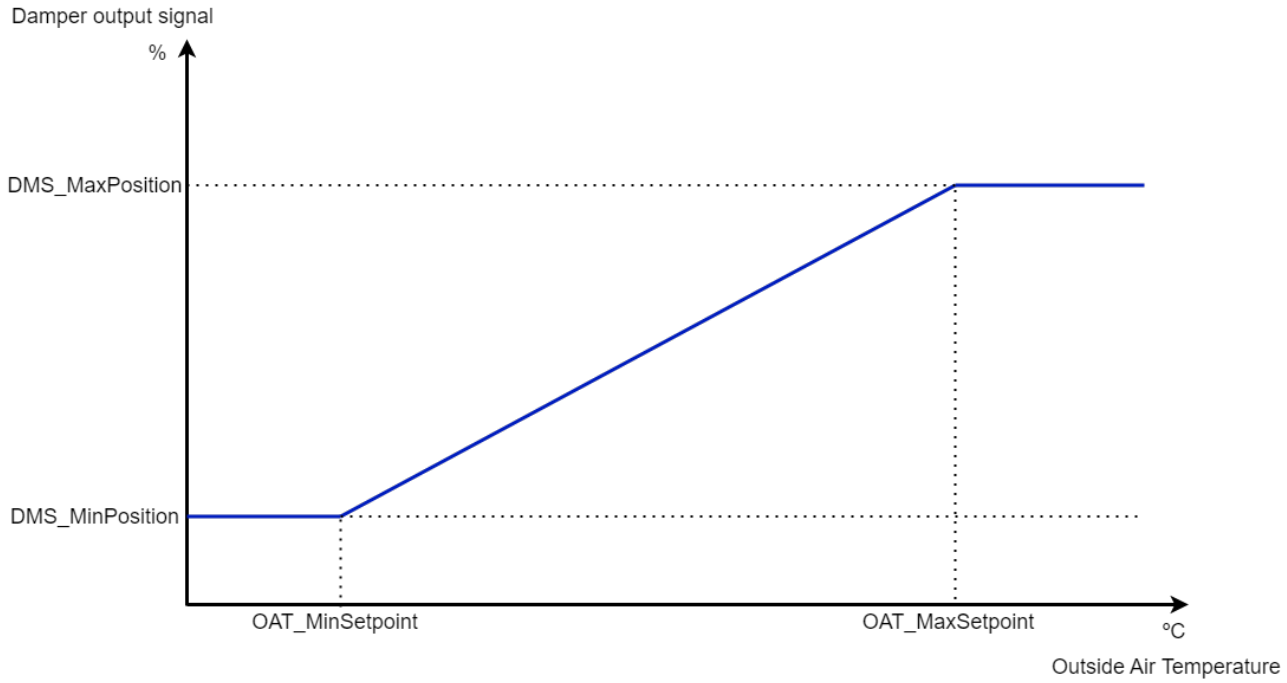


Figure 36. Fresh air damper output according to the outside air temperature

Air Quality/CO_2 Control

The fresh air damper minimum position is increased proportionally from its fixed lowest value, defined by parameter DMS_MinPosition, by the air quality signal to the maximum, defined by parameter DMS_MaxPosition, as shown in the next figure.

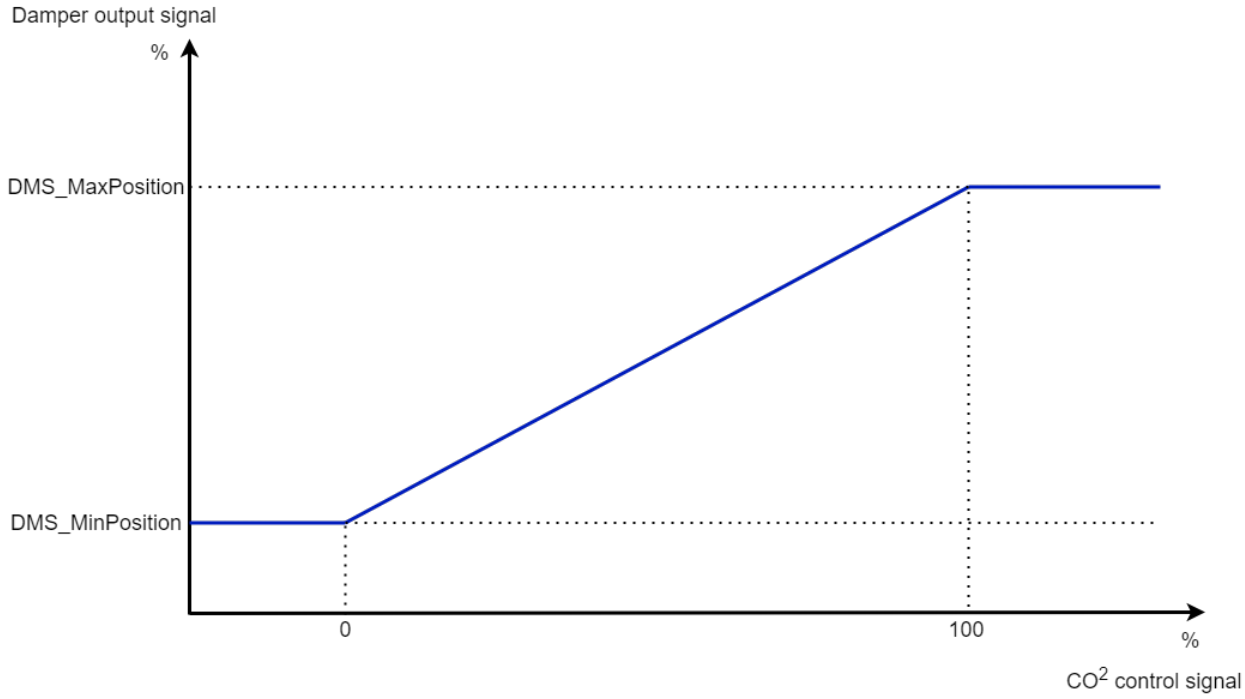


Figure 37. Fresh air damper output according to CO2

Mixing Temperature Control

In this case, the module acts as a mixed air temperature controller. The mixed air temperature control signal is based on the calculated mixed air temperature setpoint and the P-band, defined by parameter MAT_P_band, and minimum and maximum limited, as

defined by parameters MAT_MinSetpoint and MAT_MaxSetpoint. In this case, the Y or X (0-100%) signal of the damper control signal is used with mixing ait temperature control as a minimum value of both.

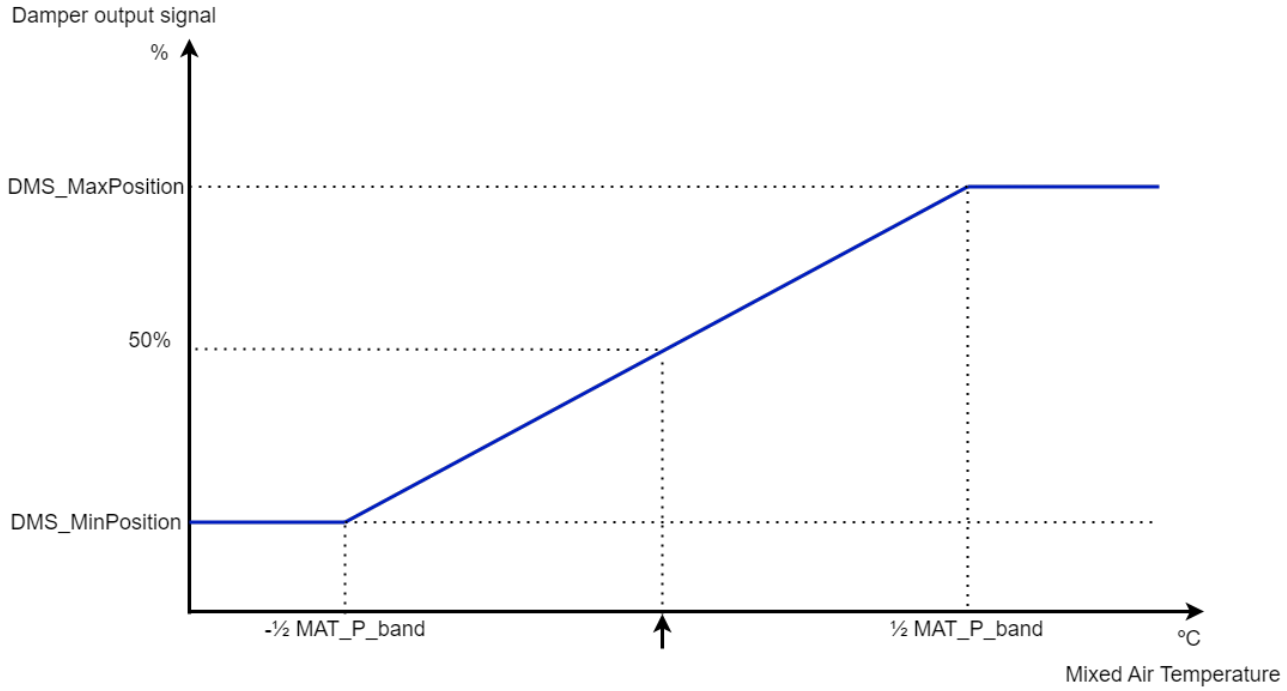


Figure 38. Fresh air damper output according to the mixing air temperature

7.1.2 Exchanger

The Exchanger module provides modulating control of different types of energy recovery equipment and incorporates a plant mode override signal. This module handles 5 selectable types of energy recovery equipment: air-liquid-air with glycol or water as a liquid medium, mixing dampers (using dampers module), heat wheel, and air-to-air plate heat exchanger. The purpose of all these systems is to recover energy from the exhaust air into the incoming outside air of an AHU. This can be used in air handling systems for heating as well as for cooling or a combination of both and results in energy savings.

The module has inputs for:

- energy recovery control signal (ERS) from the control module;
- outside air temperature (OAT);
- return air temperature (RAT);
- energy recovery temperature (ERT);
- pump/wheel status (ERStatus);
- and differential pressure switch (ERdiffPressure).

The outputs are:

- energy recovery control command (ERC);
- energy recovery pump/wheel (ERP);
- pump/wheel off;
- or fail-to-command alarm (ALARM).

Selection of Energy Recovery System Type

This module can be used for different energy recovery systems. The system types of energy recovery systems are selectable by the configuration parameter EnergyRecovMode and are as follows:

EnergyRecovMode	Energy recovery system type
Wheel (1 on LCD)	Type 1: heat wheel
Cross Flow (2 on LCD)	Type 2: air-to-air plate heat exchanger
Mixing Dampers (3 on LCD)	Type 3: mixing dampers
Twin Coil & Return Pump (4 on LCD)	Type 4: air-liquid-air with glycol as liquid medium
Twin Coil & Supply Pump (5 on LCD)	Type 5: air-liquid-air with water as liquid medium

Table 2. Energy recovery system type

The air-liquid-air system (type 4) with glycol as a liquid medium has a pump in the return pipe of the exhaust air coil and the air-liquid-air system (type 5) with water as a liquid medium has a pump in the return pipe of the outside air coil. The glycol application is mostly used in cold climates. The energy recovery systems are equipped with temperature sensors, which are connected to inputs, respectively :

- outside air temperature sensor (OAT). This sensor is mounted in the outside air duct;
- return air temperature sensor (RAT). This sensor is mounted in the return air duct at the inlet side of the energy recovery air coil;
- energy recovery temperature sensor (ERT). This sensor is mounted in the liquid part of the air-liquid-air energy recovery system (types 4 and 5). It is mounted into the return pipe of the exhaust air coil for a glycol system or into the return pipe of the outside air coil for a water system. If this sensor is not available, freeze protection is not possible.

In the case of air-liquid-air twin coils, filled with water, it is not necessary to install and connect the differential pressure switch because freeze protection will be done on the medium and there is no possibility that the exhaust coil will freeze.

Freezing of the exhaust coil will only be possible if the twin-coil system is filled with glycol, so in this case, the differential pressure sensor (ERdiffPressure) is needed.

Start-up

On initial start-up of the AHU or after a power failure, the energy recovery system will be enabled before the energy recovery assumes normal control after a delay, defined by parameter ERP_OnDelay.

Control of the Energy Recovery System

The module can work in several configurations. In a typical sequencing application, the module receives an energy recovery control signal (ERS) from the control module. The ERS can be selected by parameter ERS_RatioEnable, to be either as a position signal Y or as a correction signal X, both with a possible range of 0-100%.

In the case of a Y signal, the energy recovery output signal with minimum and maximum limitation values, defined by parameters ERS_MinRecovery and ERS_MaxRecovery, will command the heat wheel (type 1) or will be transferred directly to the valve output in an air-liquid-air (type 4 and 5) system as shown in the next figure.

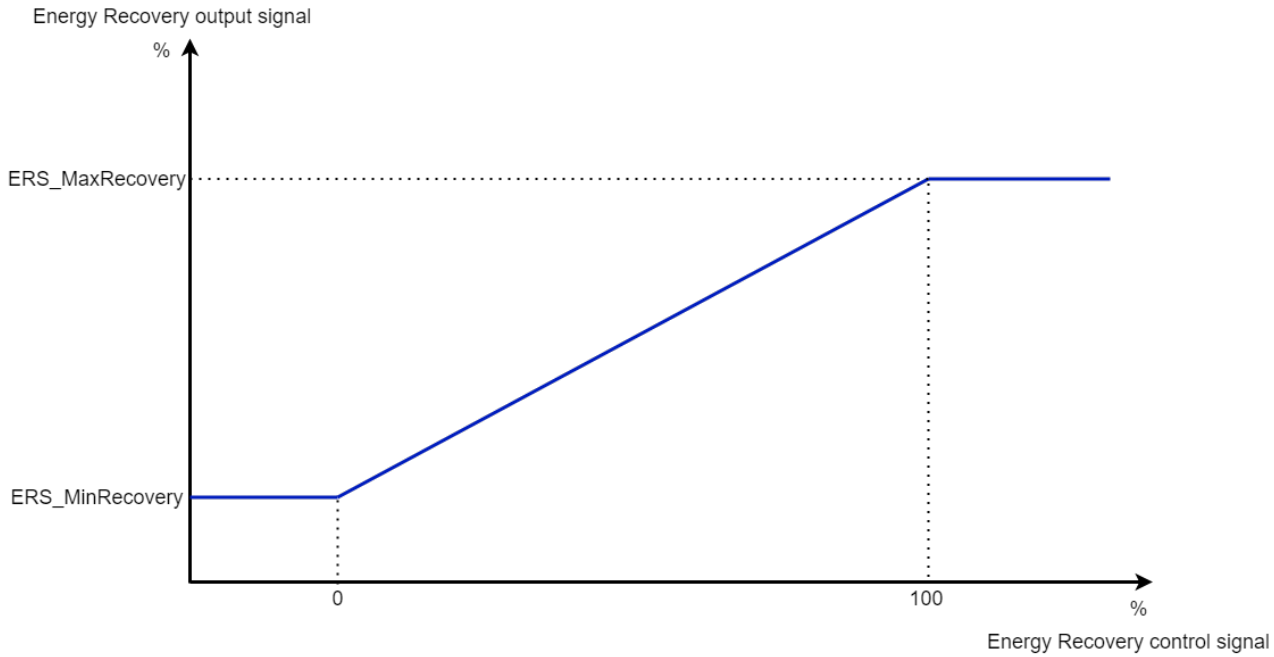


Figure 39. Energy recovery output signal

In the case of an X signal, the output signal varies from 0-100% over a sub-range of the X signal, determined by ratio sequence start- and endpoint parameters, defined by parameters ERS_StartRatioControl and ERS_StopRatioControl, and limited by minimum and maximum values, defined by parameters ERS_MinRecovery and ERS_MaxRecovery, as shown in the next figure. The endpoint parameter must always have a higher value than the start point parameter.

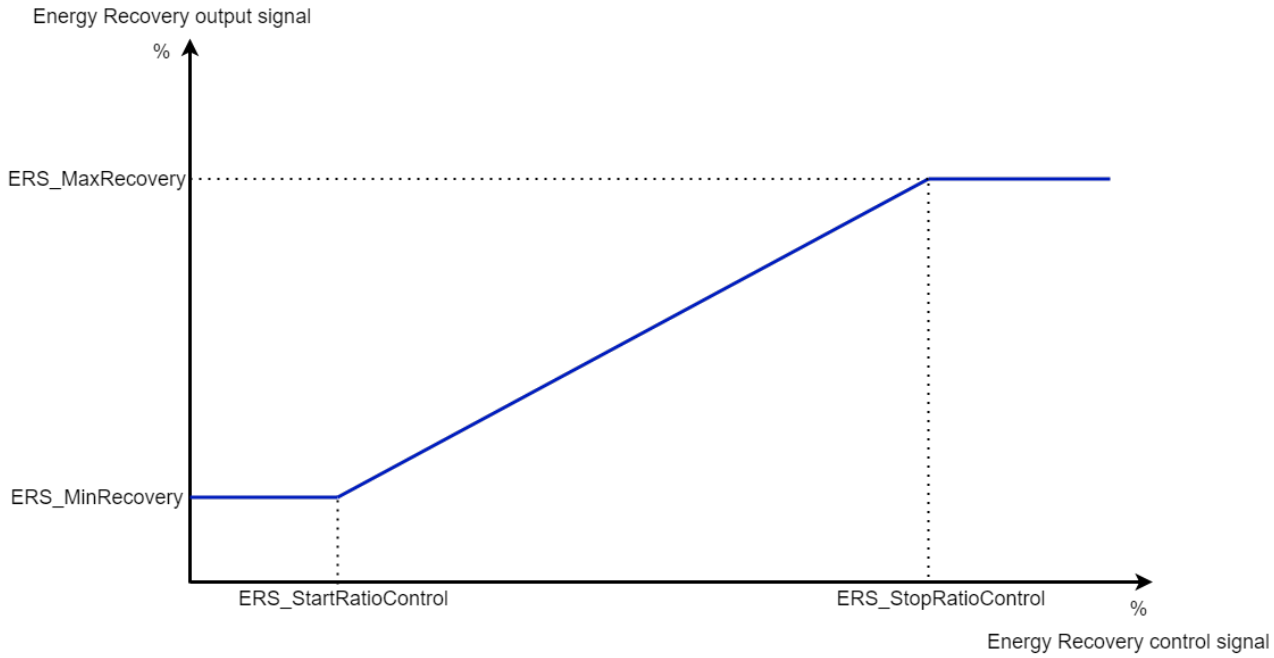


Figure 40. Energy recovery output signal with correction

Control Operation

In system types 1 (heat wheel) and 2 (air-to-air plate heat exchanger), the ERT input can be used to connect a freeze protection low limit sensor, mounted in the exhaust air duct.

In system types 4 and 5, the ERT sensor is mounted in the liquid system to maintain a minimum liquid temperature for freeze protection. The setpoint of the liquid temperature will be calculated against the outside air temperature, defined by parameters OAT_MaxSetpoint and OAT_MinSetpoint. The minimum and maximum values of the setpoint are limited by the parameters ERT_MinSetpoint and ERT_MaxSetpoint, as shown in the next figure.

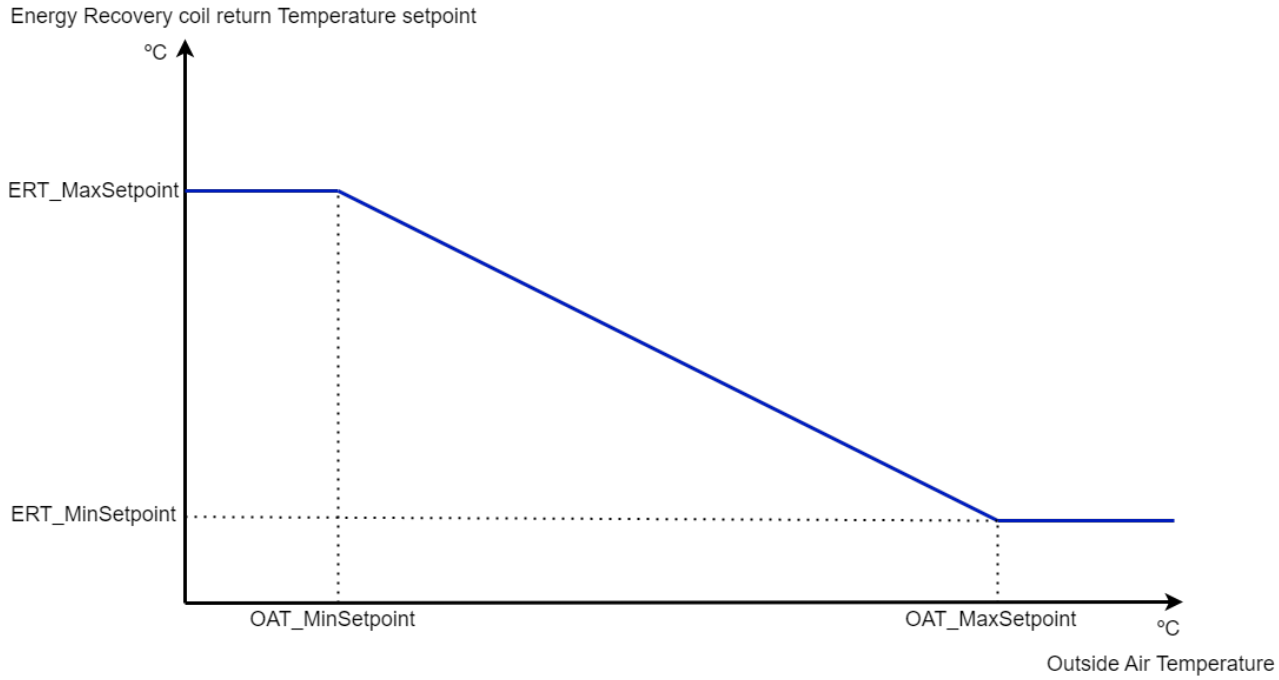


Figure 41. Energy recovery temperature setpoint

Depending on the system type, this module calculates the actuator position of system type 4 (air-liquid-air system with glycol), system type 1 (heat wheel), or system type 2 (air-to-air plate heat exchanger) as shown in the next figure.

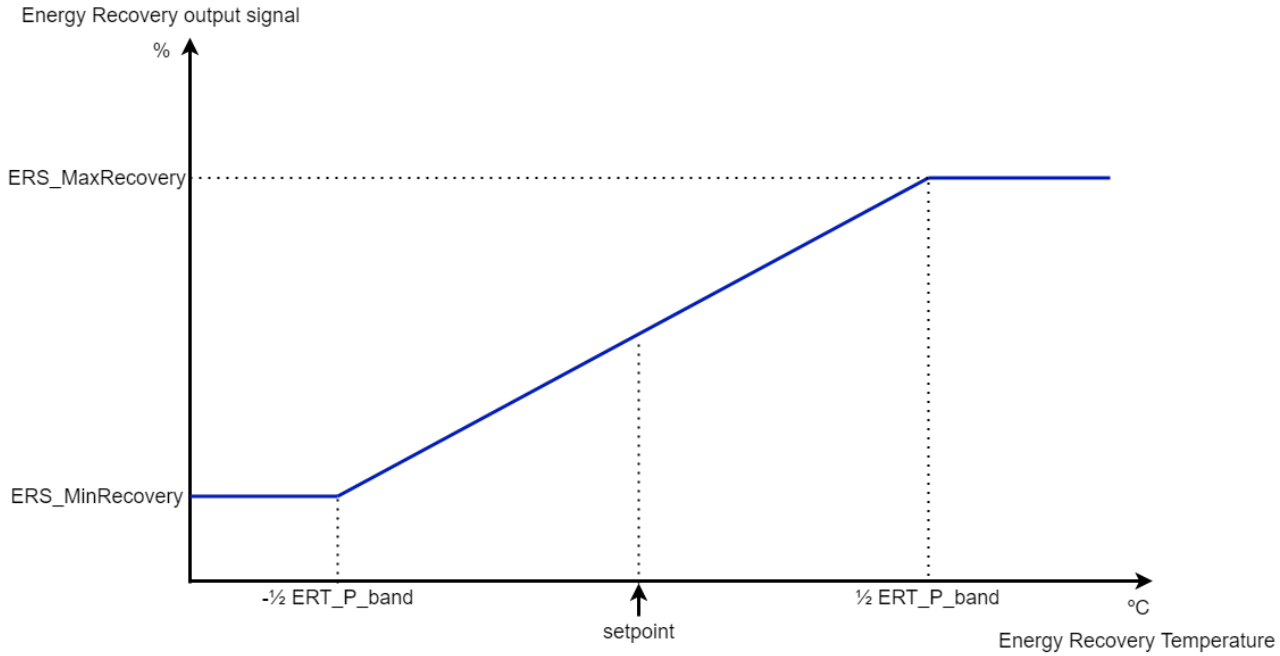


Figure 42. Energy recovery output according to the energy recovery temperature

In system type 5 (air-liquid-air, filled with water), the calculated actuator position is reversed.

Pump Command or Wheel Release

The energy recovery pump in system types 4 and 5 or the heat wheel (type 1) is enabled when the energy recovery control output is more than 3% (fixed) and will be switched off after a delay, defined by parameter ERP_OffDelay when the control signal value is below 1% (fixed). The pump or heat wheel is also enabled if the outside air temperature is below the value of parameter OAT_FrostProtection or during the pump exercise. In system type 1 (heat wheel) the output to the wheel can be selected, continuously or by plant mode override, as defined by parameter ERP_WheelRelease.

Pump/Wheel Alarms

In system types 1, 4, and 5 fail-to-command, the pump-/wheel-off alarms are generated if the pump/wheel status is connected.

Selection of Alarms or a Fail-to-command Alarm

With the parameter ERP_StatusAlarmDelay (delay status alarm) it is possible to select different kinds of alarms, as shown in the next table.

ERP_StatusAlarmDelay setting	Alarm output behavior
> 1	The status is monitored and differentiated off-alarms are generated, after the delay of parameter ERP_StatusAlarmDelay
= 1	The status input will be handled as a failure input without delay (a logic 1 at the input means a failure condition)
= 0	No monitoring is done and no alarms are generated

ERP_StatusAlarmDelay setting	Alarm output behavior
< 0	The status is monitored and a fail-to-command alarm is generated at the on-alarm output, after the (absolute) time of the delay, defined by parameter ERP_StatusAlarmDelay

Table 3. Alarm output behavior

Pump and Valve Exercise

This is done in sequence by commanding the internal variables Pump_Exercise (for pump and valve in Inputs section), by default, it is run every week on Sunday (internal variable DayOfWeek in the Inputs section) at 1am (internal variable ExerciseHour in the Inputs section). The pump on and valve open time is defined by the parameter ERP_Pmp_Vlv_Exercise (this value should not be smaller than the valve actuator runtime).

It is possible to disable pump and valve exercises, as shown in the next table.

ERP_Pmp_Vlv_Exercise setting	Pump and valve exercise behavior
> 0	Both pump and valve exercises will be executed
= 0	No pump and valve exercise will be executed
< 0	Only pump exercise will be executed

Table 4. Pump and valve exercise behavior

If the Pump_Exercise command is given and the pump is off, the pump will start. After a delay, defined by parameter ERP_Pmp_Vlv_Exercise, the pump will stop and the valve will be opened to 100% during the time of parameter ERP_Pmp_Vlv_Exercise. If the pump runs and the Pump_Exercise command is given no pump test will be done, but as soon as the pump stops the valve test will be executed as shown in the next figure.

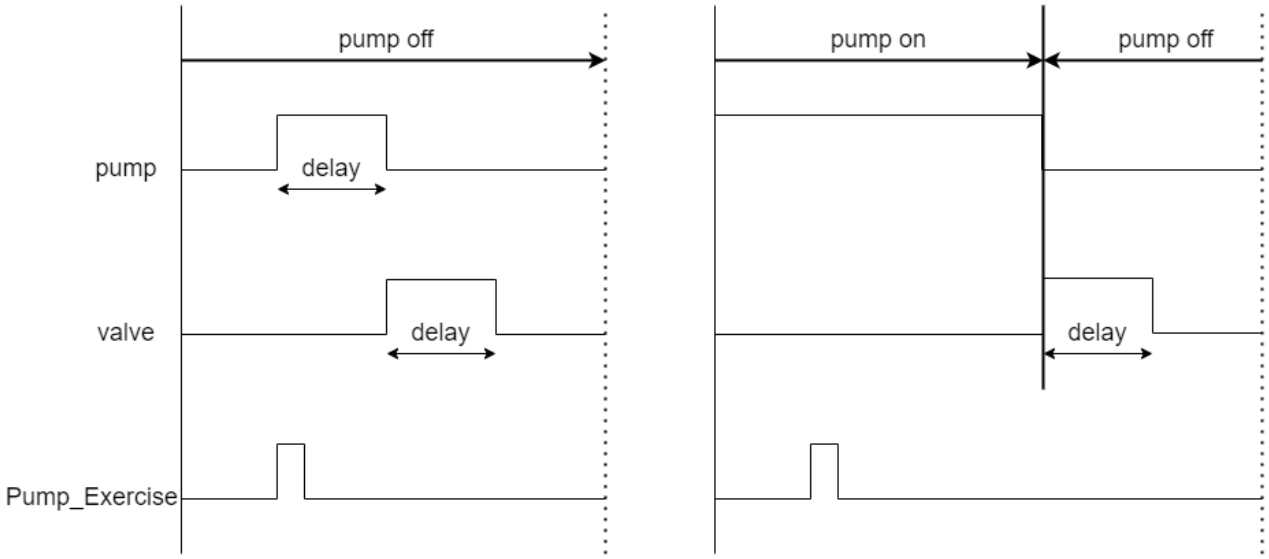


Figure 43. Pump and valve exercise

Differential Pressure Protection

In system types 1, 2, 4, and 5, a differential pressure switch (ERdiffPressure) is available for safety reasons. When this switch activates, the ERC output signal of the different energy recovery system types will be according to the positions, as shown in the next table.

ER system type	ERdiffPressure off (=false)	ERdiffPressure on (=true)
1	Control	0%
2	Control	0%
4	Control	0%
5	Control	100%

Table 5. Differential pressure switch

7.1.3 Heater (Preheater or Reheater)

The Heater module provides modulating control of the heating coil valve actuator and can be selected for a heater or preheater and reheater. A damper enables a signal to be set if the coil's return water condition is normal.

The module has inputs for;

- the heating control signal (HTS);
- return water temperature (RWT);
- heating pump status (HPumpStatus);
- and frost protection (FEZ).

The outputs are:

- heating valve (HTV);
- heating pump command (HPU);
- pump-off alarm fail-to-command alarm (ALARM);
- and damper enable signal (DME).

Pump-off or fail-to-command alarms can be generated, provided that the pump status is connected. Pump and valve exercise is part of the module.

Note: RWT and FEZ do not apply to reheater.

Damper Enable Output

On start-up, the heating valve and pump assume normal control. When the outside air temperature is below the limit, which is defined by parameter OAT_FrostProtection, the return water temperature RWT should reach the calculated return water temperature setpoint (minus ½ RWT_P_band), before the damper enables signal DME to be set to on. This feature reduces the risk of frost damage on initial plant start-up. If the time, to reach the mentioned temperature, exceeds the delay, defined by parameter DME_OnDelay, DME will be active.

Note:

- As long as the outside air temperature is below the value of parameter OAT_FrostProtection and the coil return water temperature sensor is not present, the damper will be enabled after the delay, as defined by parameter DME_OnDelay.
- As long as the outside air temperature is below the value of parameter OAT_FrostProtection and return water temperature sensor is not present, the valve will be set to parameter HTV_FrostProt_ValveUp and is returned to its normal control position via a ramp function defined by parameter HTV_Ramp.
- As long as the outside air temperature is above the value of parameter OAT_FrostProtection plus the fixed differential of 1K, the delay to enable DME will be ignored.

Modulating Control of Valve Actuator

The module can work in several configurations. In a typical sequencing application, the module will receive a heating control signal (HTS) from the control module. The HTS can be selected, defined by parameter HTS_RatioEnable, to be either as a position signal Y or as a correction signal X, both within a range of 0-100%.

In the case of a Y signal, the input is transferred directly to the valve output as shown in the next figure.

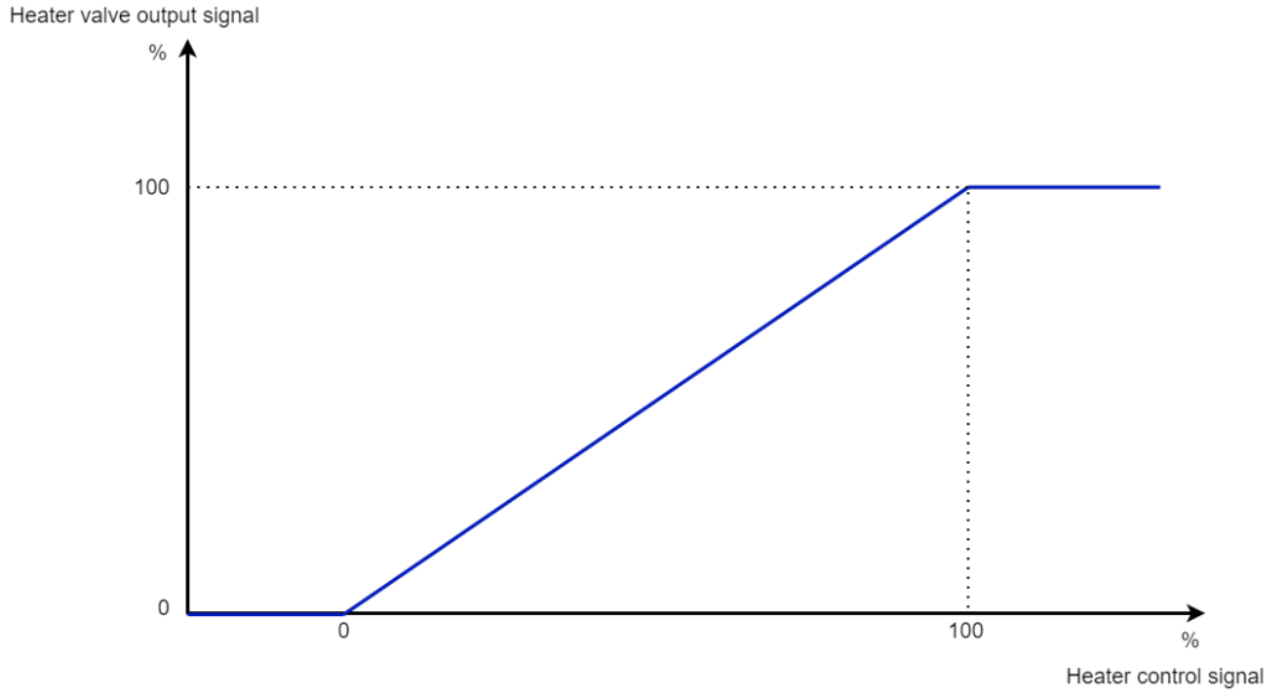


Figure 44. Heater output signal

In the case of an X signal, the signal sent to the valve output varies from 0-100% over a sub-range of the X signal, determined by a ratio sequence with start and stop points, defined by parameters HTS_StartRatioControl and HTS_StopRatioControl.

Selection of Heating Coil Type

The coil type can be selected by parameter HeaterMode as a heater, or a preheater & a reheater, as shown in the next figure.

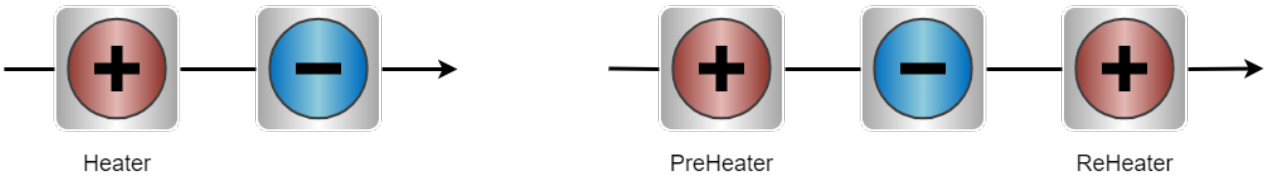


Figure 45. Coil type

The coil type defines how the heating valve controls according to humidification and dehumidification as shown in the next table.

Heater Mode	Type	Humidification	Dehumidification
Heater (1 on LCD)	Heater	Controlled by temperature	Controlled by temperature
PreHeater and ReHeater (2 on LCD)	Preheater and reheater	Preheater controlled by temperature, reheater closed	Preheater closed, reheater controlled by temperature

Table 6. Heating valve control according to humifidication and dehumidification

Return Water Temperature Control

Minimum Temperature Control

If the heating coil works as a heater or preheater, optionally the coil can be equipped with a coil return water temperature sensor to protect against undesired low temperatures. If this sensor is available a minimum return water temperature setpoint can be calculated. This setpoint is outside air temperature compensated between the values, defined by parameters OAT_MaxSetpoint and OAT_MinSetpoint, in order to override the valve output to open.

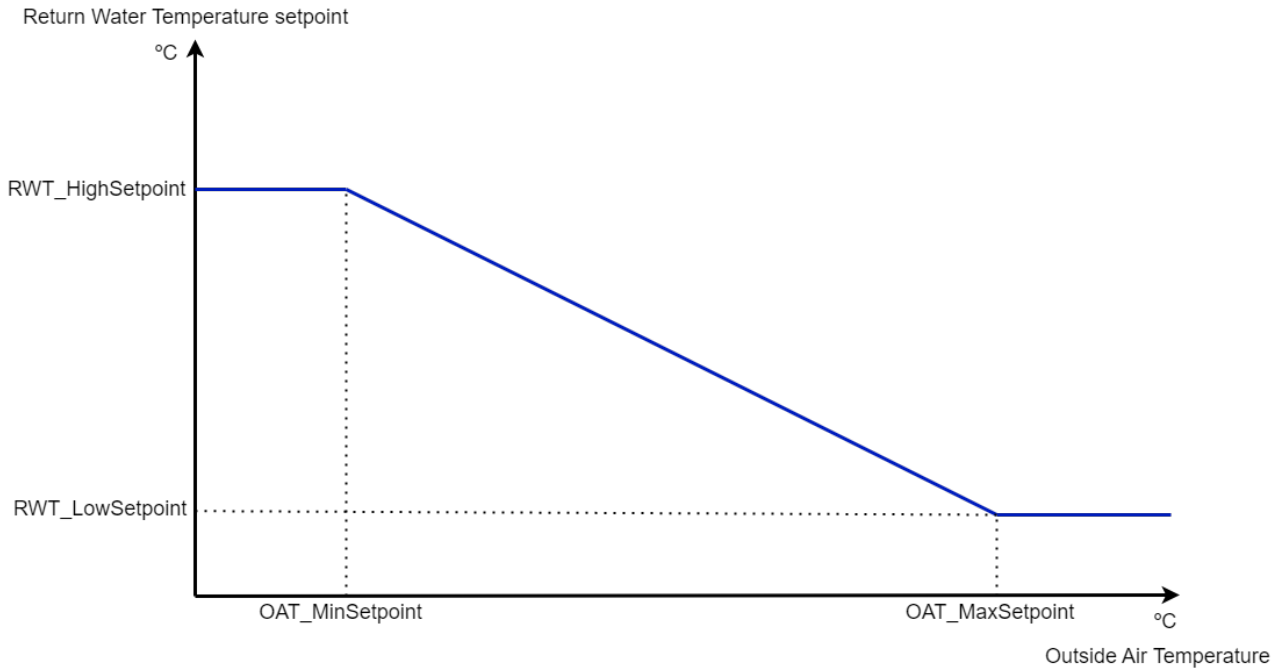


Figure 46. Return water temperature setpoint according to the outside air temperature

Note: this minimum return water temperature control is only active when the outside air temperature is lower than the value of parameter OAT_FrostProtection.

Depending on the calculated setpoint and the P-band, defined by parameter RWT_P_band, the control output varies from 0-100% as shown in the next figure.

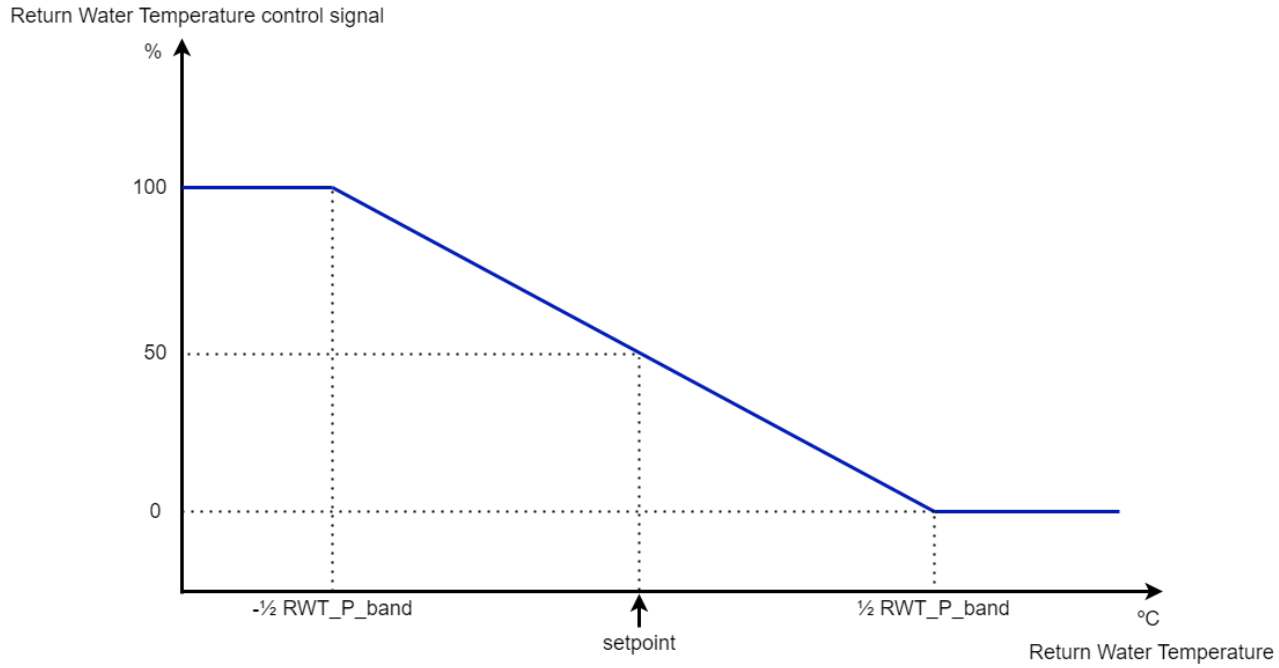


Figure 47. Return water control signal according to the return water temperature

Maximum Temperature Control

The coil return water temperature RWT is also limited by a maximum setpoint, as defined by parameter RWT_MaxSetpoint, in order to override the heating valve output to close if the return water temperature becomes too high (this function is required in case of district heating applications).

If return water temperature is present, then the temperature control with the highest demand controls the valve.

Frost Protection

To protect the heating coil against freezing a frost alarm procedure is started as soon as a frost alarm condition occurs. If the frost alarm condition is returned to the normal position a frost recovery procedure starts.

- Frost alarm procedure:

If a frost alarm occurs the following actions will be executed:

1. The pump starts.
2. The heating valve gets a predefined position, according to the value of parameter HTV_FrostProt_ValveUp.
3. If a coil return water temperature sensor is available, the return water temperature setpoint is set to the value of parameter FEZ_RWT_SptUp.

- Frost recovery procedure:

When the frost alarm condition returns to normal, the following actions will be executed:

1. If a coil return water temperature sensor is available, the return water temperature setpoint, raised by the value in parameter FEZ_RWT_SptUp, is returned to its normal control value via a ramp function defined in FEZ_SetupRamp.

The ramp function to normal control is shown in the next figure.

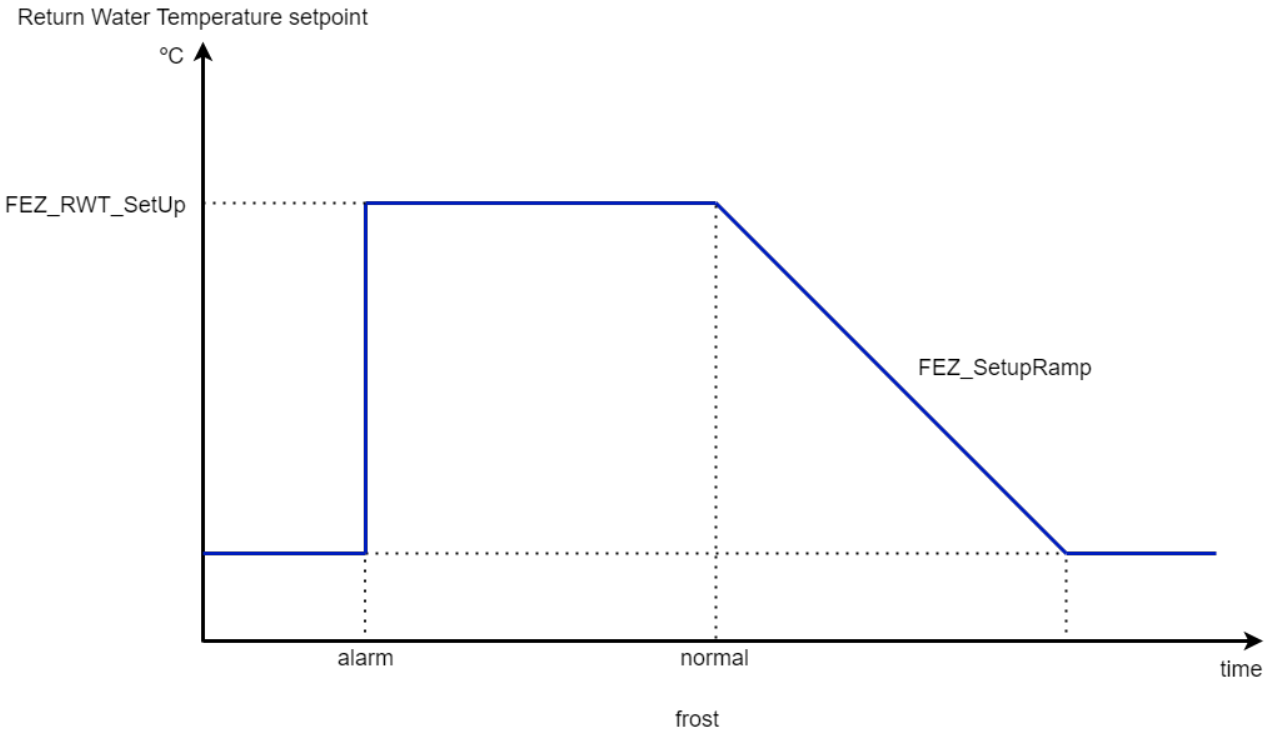


Figure 48. Ramp function for return water temperature setpoint

If no sensor (return water) is available, the predefined valve position, defined by parameter HTV_FrostProt_ValveUp, is returned to its normal control position via a ramp function defined in HTV_Ramp, as shown in the next figure.

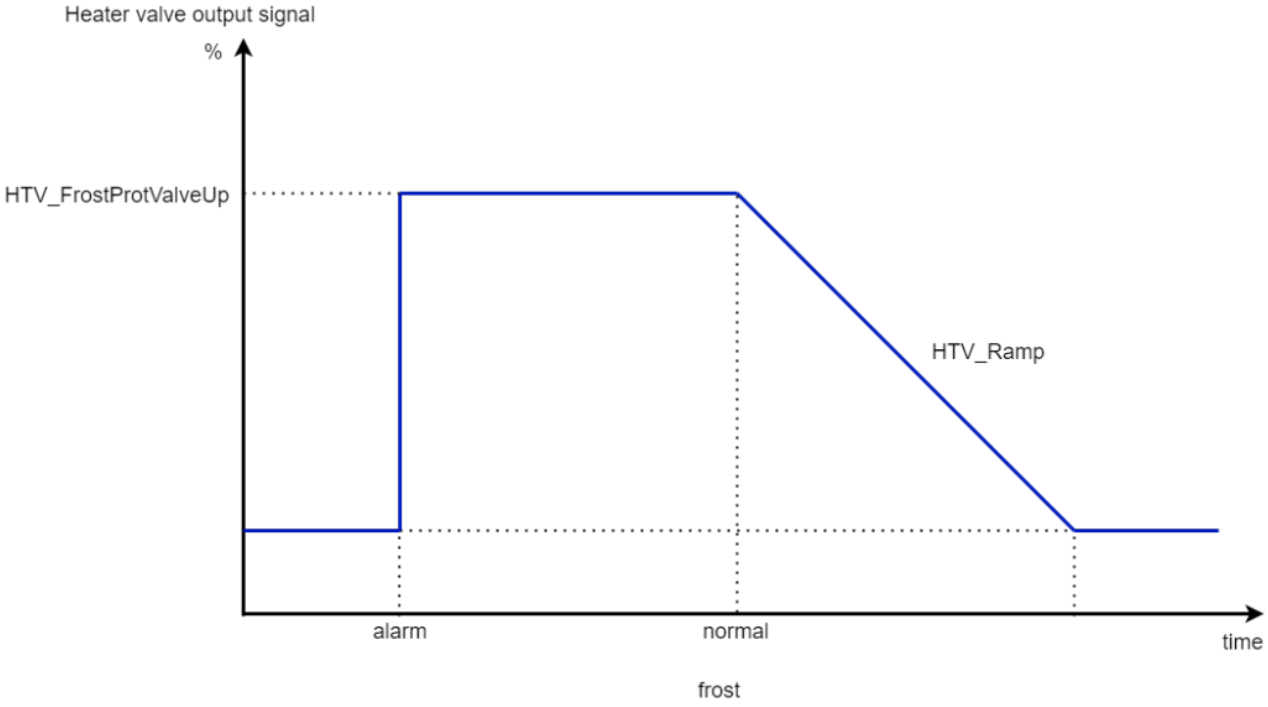


Figure 49. Ramp function for heater valve output (without RWT sensor)

Pump Control

If the parameter HPU_Enable is set to True, the pump is enabled. In this case, the pump starts when the heating valve opens more than 3% (fixed), and stops after an adjustable delay, defined by parameter HPU_OffDelay, when the heating valve output value goes

below 1% (fixed). The pump runs continuously if the outside air temperature is below the value in parameter OAT_FrostProtection or in case of a frost alarm condition (Thermostat=True), even if the power demand program has commanded the air handling unit off.

During initial start-up, the pump starts after a delay, defined by the parameter HPU_OnDelay.

Pump Alarms

If the pump status (HPumpStatus..) is connected pump-off or fail-to-command alarms are generated. The pump alarms are delayed as defined by the parameter HPU_StatusAlarmDelay. When a pump-off alarm occurs and the outside air temperature is below the value of parameter OAT_FrostProtection, the air handling unit will be switched off. This function can be enabled by the parameter DME_EmergencyStop.

Selection of Alarms or a Fail-to-command Alarm

With the parameter HPU_StatusAlarmDelay, it is possible to select different kinds of alarms, as shown in the next table.

HPU_StatusAlarmDelay setting	Alarm output behaviour
> 1	The status is monitored and differentiated off-alarms are generated, after the delay of parameter HPU_StatusAlarmDelay
= 1	The status input will be handled as a failure input without delay (a logic 1 at the input means a failure condition)
= 0	No monitoring is done and no alarms are generated
< 0	The status is monitored and a fail-to-command alarm is generated at the on-alarm output, after the (absolute) time of the delay, defined by parameter HPU_StatusAlarmDelay

Table 7. Alarm output behavior

Periodic Pump and Valve Exercise

This exercise is done in sequence by commanding the internal variable Pump_Exercise (for pump and valve in Inputs section), by default, it is run every week on Sunday (internal variable DayOfWeek in the Inputs section) at 1am (internal variable ExerciseHour in the Inputs section). The pump on and valve open time is defined by the parameter HPU_Pmp_Vlv_Exercise (this value should not be smaller than the valve actuator runtime).

It is possible to disable pump and valve exercises, as shown in the next table.

HPU_Pmp_Vlv_Exercise setting	Pump and valve exercise behavior
> 0	Both pump and valve exercises will be executed
= 0	No pump and valve exercise will be executed
< 0	Only pump exercise will be executed

Table 8. Pump and valve exercise behavior

If the Pump_Exercise command is given and the pump is off, the pump will start. After a delay, defined by parameter HPU_Pmp_Vlv_Exercise, the pump will stop and the valve will be opened to 100% during the time of parameter HPU_Pmp_Vlv_Exercise. If the pump runs and the Pump_Exercise command is given no pump test will be done, but as soon as the pump stops the valve test will be executed, as shown in the next figure.

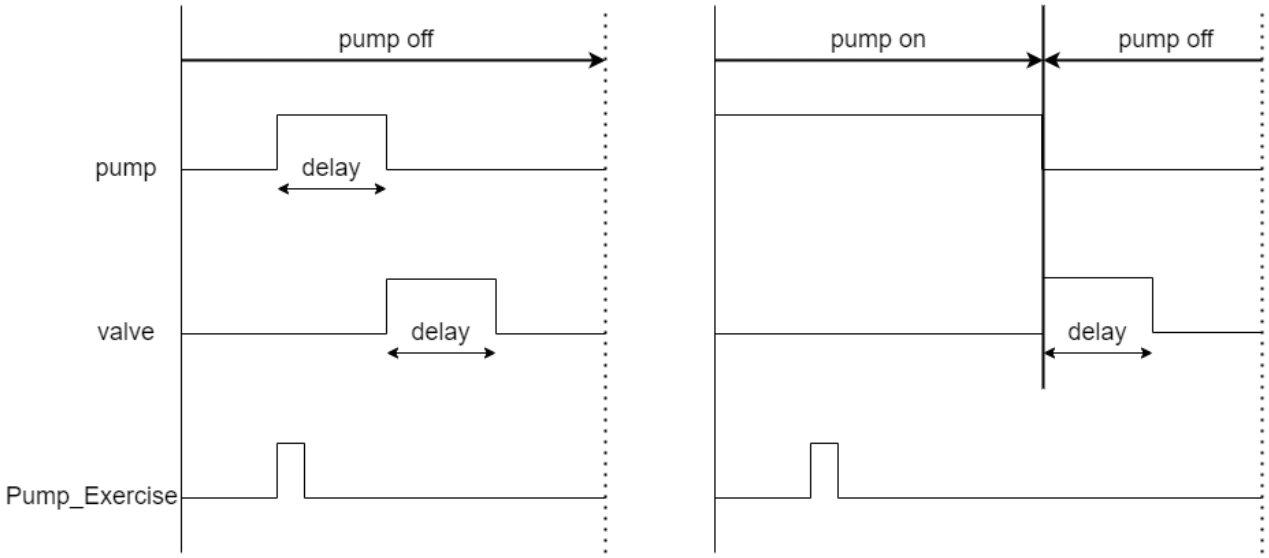


Figure 50. Pump and valve exercise

AHU Stops on Pump-off Alarm at Low Outside Air Temperature

If the outside air temperature is below the value of parameter OAT_FrostProtection and the pump would fail, which means that no adequate frost protection can be done, the total AHU will be stopped when parameter DME_EmergencyStop was set to the value of True.

In this specific case, the module will disable its DME output immediately.

Tips:

- Sometimes, the preheater consists of more than one individual heating coil, each one with its own control valve. In this case, a separate module should be applied for each heating coil and the coils should be sequenced by setting the ratio function active, inside the respective parameter lists to decide the HTS signal in several sequence ranges. For instance, when there are four coils, the first one works from 0-25%, the second one from 25-50%, the third one from 50-75%, and the last one from 75-100% (of the HTS-signal).
- It is also possible that the preheater is designed too small (on purpose, in order to get better controllability) and the reheater has to be used in addition to the preheater, or in case of the need for reheating when water spray humidification is used and the supply air has to be reheated. In this case, the same trick can be done: Enable the ratio function only in the parameter list of the preheater and set its ratio values for instance from 0-50% (of the HTS-signal). The heater mode should be defined as a preheater and a reheater coil so it works all the time when heating is needed independent of the HumMode. There is no need to enable the ratio function within the reheater because it should work on the full range of the HTS signal (0-100%).

7.1.4 Cooler

The Cooler module provides modulating control of the valve actuator of the cooling coil from air handling units, with plant and humidity mode override signals.

The module has inputs for the cooling control signal (CCS), and dehumidification control signal (DEH).

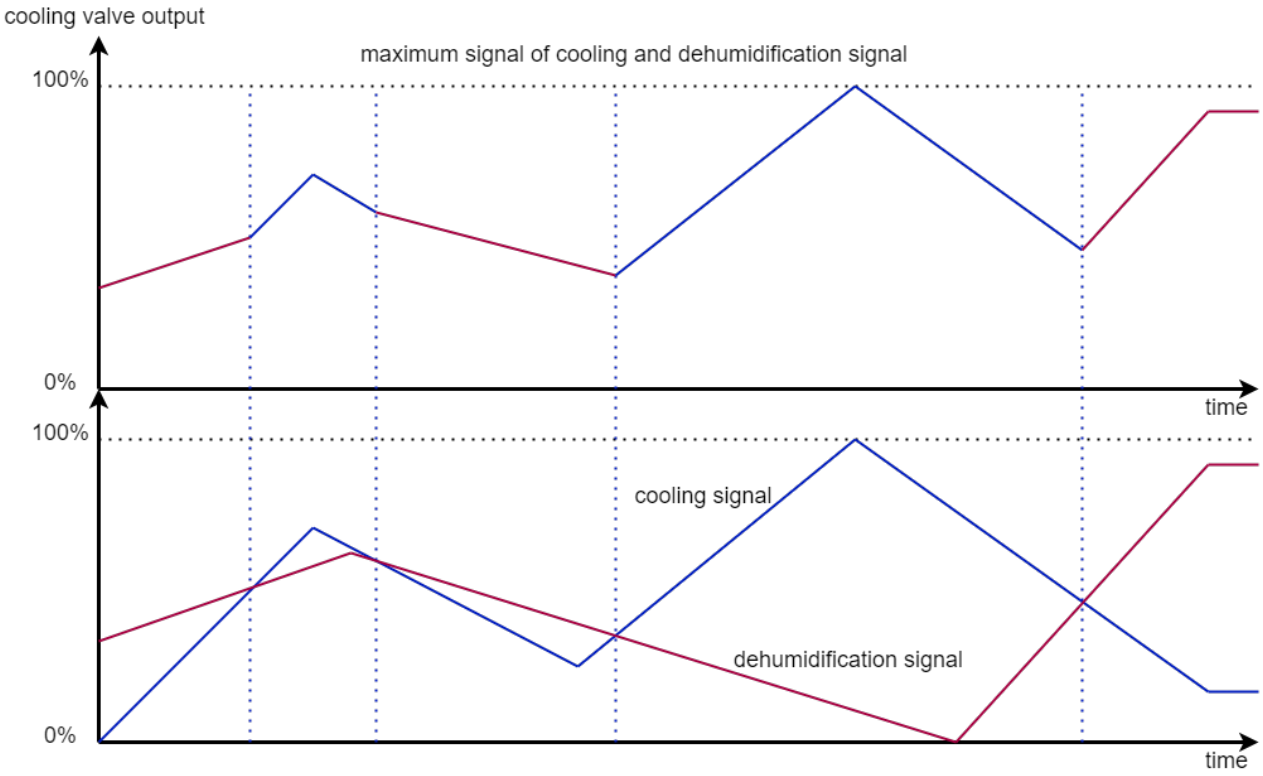


Figure 51. Cooling output signal

The output (CCV) is a 0-100% control signal to the actuator of the cooling coil valve. The valve can be forced to a closed position if the outside air temperature is too low. A valve exercise is part of the control logic.

Modulating Control of the Valve Actuator of the Cooling Coil

The module can work in several configurations. In a typical sequencing application, the module receives a cooling control signal either as position signal Y or correction signal X from the control module, both with a possible range of 0-100%.

In case of a Y signal the signal will be transferred directly to the valve output. The decision for cooling or dehumidification is already made in the Control module. If for some reason a separate dehumidification input DEH is used, then the module will transfer the highest of the two signals (cooling or dehumidification) to the cooling valve output.

In the case of an X signal, which can be enabled for temperature or dehumidification control, respectively defined by parameters CCS_RatioEnable and DEH_RatioEnable, the signal sent to the valve output varies from 0-100% over a sub-range of the -X- signal, determined by ratio sequence start and end parameters, respectively CCS_StartRatioControl/CCS_StopRatioControl and DEH_StartRatioControl/ DEH_StopRatioControl, as shown in the next figure.

Note: The end parameter must have a higher value than the start parameter.

Also in this case the cooling coil module transfers the highest of the two signals (cooling or dehumidification) to the valve output.

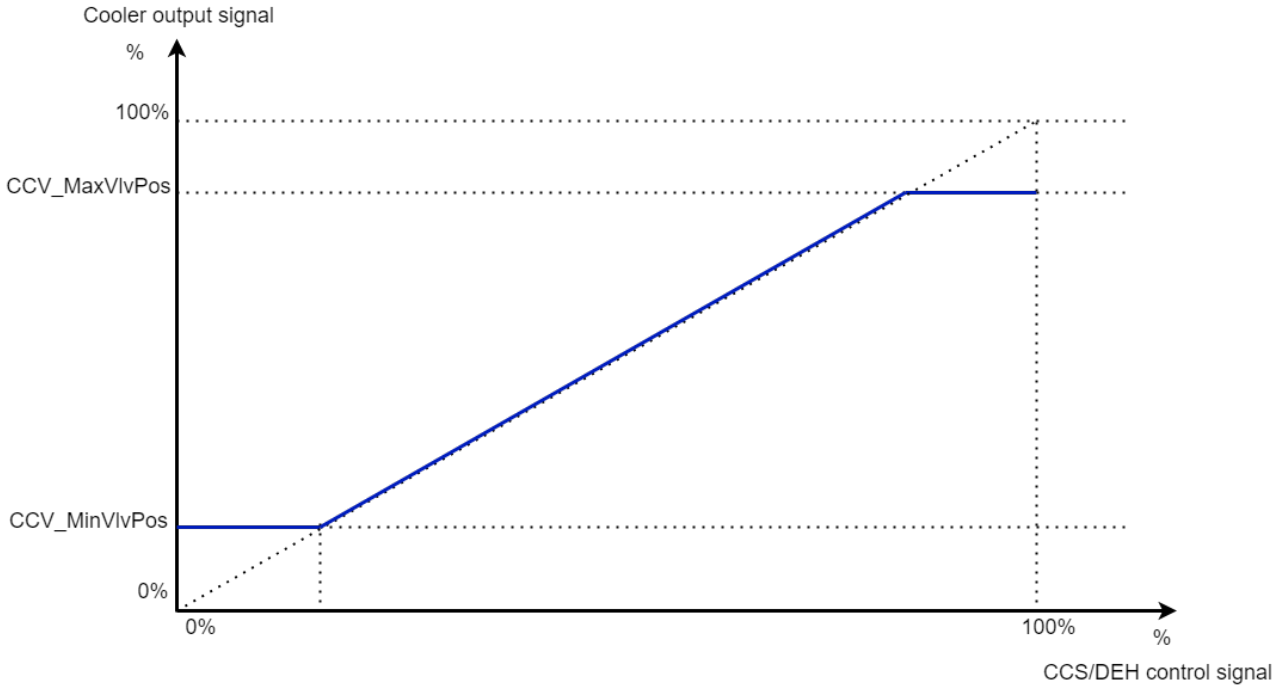


Figure 52. Cooler output signal

Minimum and Maximum Limits for the Actuator Position Signal

The minimum and maximum valve positions during control are defined by the parameters CCV_MinVlvPos and CCV_MaxVlvPos. Limitation of the valve position is mostly needed when DX-expansion valves are used (see previous figure).

Cooling Disabled on Humidification

Cooling is disabled during humidification when the HUM_Mode signal from the Humidifier module equals -1-. This function is selectable by the parameter CCV_CoolOnHumDisable.

Cooling Disabled Based on the Outside Temperature

If the outside air temperature is below a certain value, e.g. 10-14 °C and there is no need for either cooling or dehumidification, the valve can be forced to a closed position. The value is defined by the parameter OAT_CoolerLowLimit and has a fixed differential of 1K.

Note: To disable this function set parameter OAT_CoolerLowLimit to a value of -50°C.

Ramped Opening of the Valve at the Cooling Start

On plant start-up and each time the valve opens from 0%, the actual valve output signal is ramped open to its calculated position during a delay, defined by parameter CCV_VlvRamp, as shown in the next figure. This is done to prevent excessive disturbance of the load of the chiller, caused by a sudden increase in chilled return water temperature. The function is also useful when controlling cooling coils by 2-way valves with a high-pressure cooling medium.

Note: To disable this function set the value defined by parameter CCV_VlvRamp to 100%.

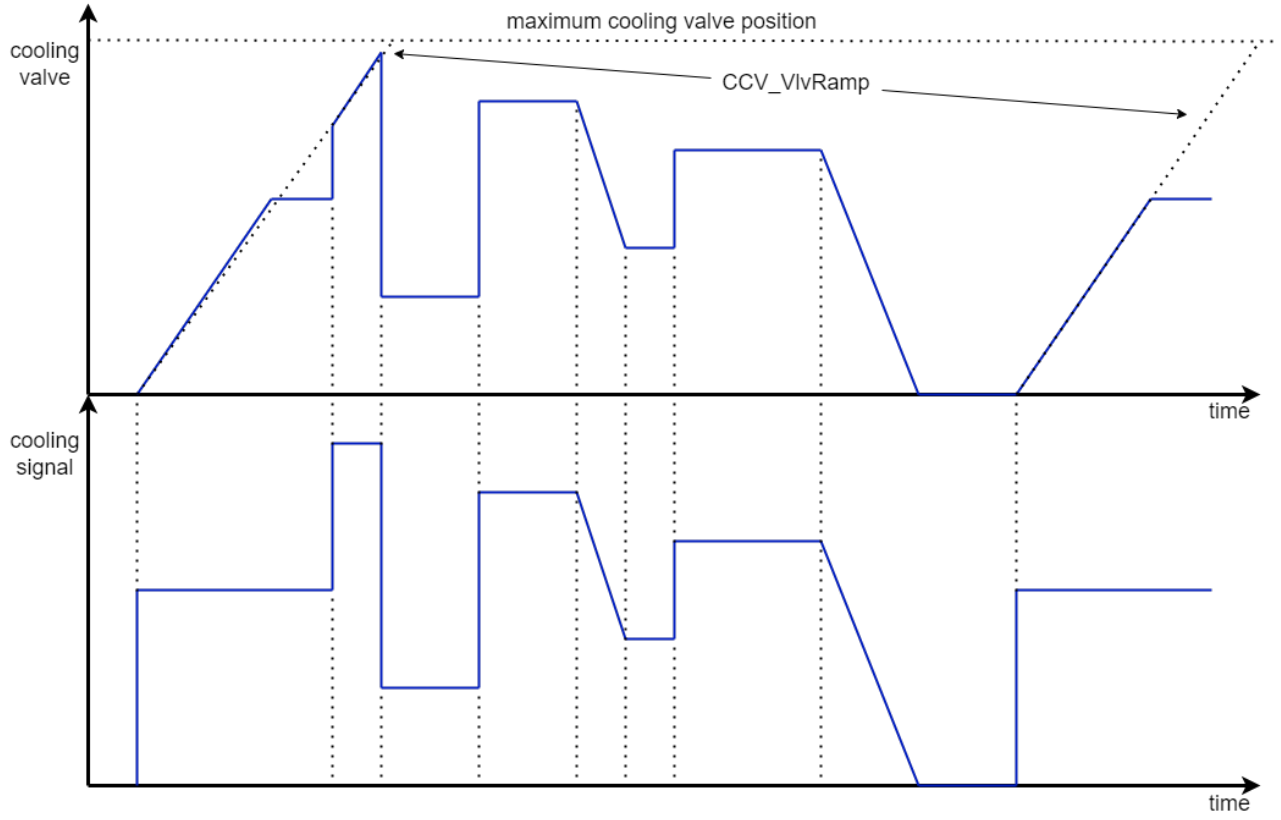


Figure 53. Ramp function for cooling valve

Periodic Valve Exercise

When the plant is off, this exercise is done in sequence by commanding the internal variable Valve_Exercise (for valve in Inputs section), by default, it is run every week on Sunday (internal variable DayOfWeek in the Inputs section) at 1am (internal variable ExerciseHour in the Inputs section). The valve open time is defined by the parameter CCV_Vlv_Exercise, which value should not be less than the valve actuator runtime.

Note: If parameter CCV_Vlv_Exercise is set to -0-, the valve exercise will be disabled.

Minimum Limit Override Control

In this case, the CCS is connected to the cooling signal of the control module. The input CoolLimTemp will be used as a low-limit sensor. The absolute minimum setpoint is defined by the parameter LIM_Setpoint, the proportional band by parameter LIM_P_band and the integral time by parameter LIM_I_time. After start-up, when the PlantMode code equals a value 1, 2, 4, 5 and the FanDiffPressure input becomes true (= 1), the limitation control starts as a P controller. After a delay equal to the I-time, the integral part will be activated.

The following diagrams show the high-limit control signal with PI- and P-control.

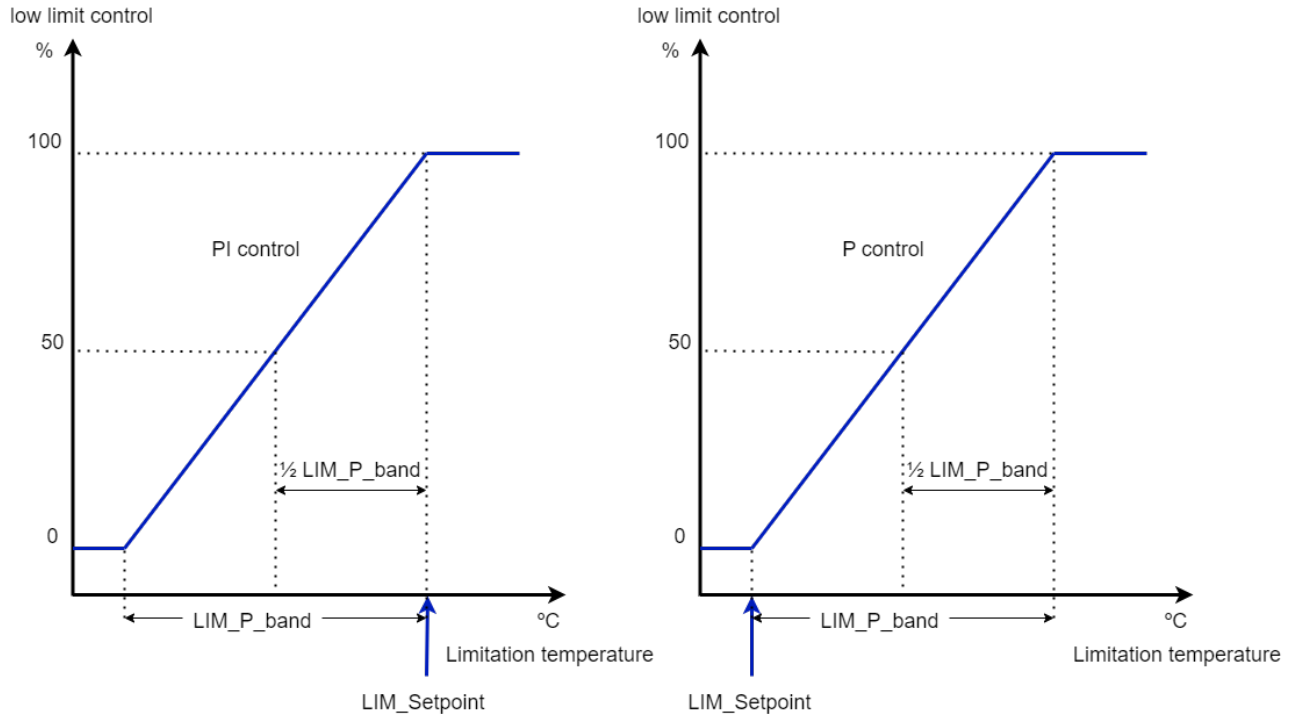


Figure 54. Low limit control with PI- and P-control according to the limitation temperature

Note: If a limitation sensor is connected, the maximum of the two control signals CoolLimTemp and CCS will be used to calculate the CCV value.

7.1.5 Fans

The Fans module can be used wherever there is a requirement for variable speed control of a fan. It can be used for supply fans as well as for exhaust fans and incorporates plant override mode signals.

The module also provides filtering of the duct static pressure. The duct static pressure is filtered to provide a smoothed value, which is used to eliminate sudden duct static pressure variations and thus provides a more stable operation of the duct static pressure control.

The module has inputs for:

- duct static pressure sensor (DSP);
- fan control signal (FCS) from the Control module;
- duct static pressure control;
- fan pressure switch (FanDiffPressure);
- operation switch;
- and fan enable signal (FNE) from the damper control.

The fan speed control between minimum and maximum limits is adjustable by parameter settings. Fan speed changes are always ramped up and down.

The module has outputs for:

- fan on/off (FansCmd);
- variable speed control for discharge and return fans (DischFan, RetFan);
- and fan belt alarm (ALARM).

Fan Enable Input

On initial start-up after the fan enable signal (FNE) is true, or after a power failure, there is a delay defined by parameter FSC_OffOnDelay, after which the fan release signal is energized and the fan can start. The fan control signal (FCS) to the variable speed controller will be ramped to the fan speed in accordance with the fan speed control output (FSC) and to the maximum fan speed defined by parameter FSC_MaxSignal, if necessary. This fan control signal (FCS) can come from the Control module and the duct static pressure control. The ramp-up time is adjustable by the parameter FSC_Ramp and occurs when the fan goes to a higher speed. Ramping up and down will always take place in percent per minute.

Fan Speed Control Output (FSC) Ramped up After Start-up

The fan speed control output of the duct static pressure control module will be only once ramped up in percentage per minute, as defined by parameter FSC_Ramp, from zero to the desired controlled level, as shown in the next figure.

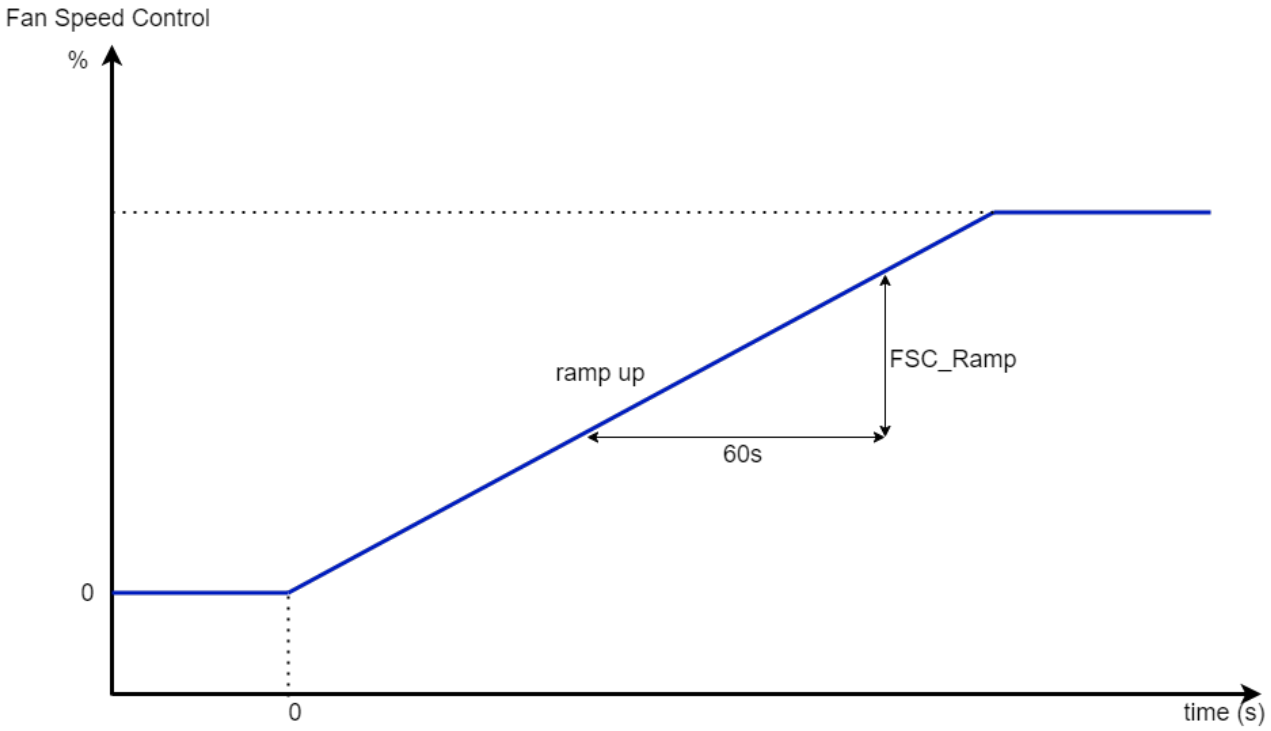


Figure 55. Ramp function for fan speed control at start-up

Note: The control signal of the Duct static pressure control has higher priority than Fan speed control and will be omitted from the FSC output of the module if duct pressure sensors are disconnected.

Fan Speed Control

The variable fan speed control from 0% to 100% can be adjusted between minimum and maximum limits as defined by parameters FSC_MinSignal and FSC_MaxSignal. In a typical sequencing application, the module will receive a fan control signal (FCS) from the Control module.

Adjustable Ramp-up and -down of the Fan Speed

During normal operation, the fan speed changes from a lower speed to a higher or opposite according to the fan speed control FSC. The speed changes are always ramped up and down in percent per minute and defined by parameter FSC_Ramp and limited to the maximum speed defined by parameter FSC_MaxSignal as shown in the next figure.

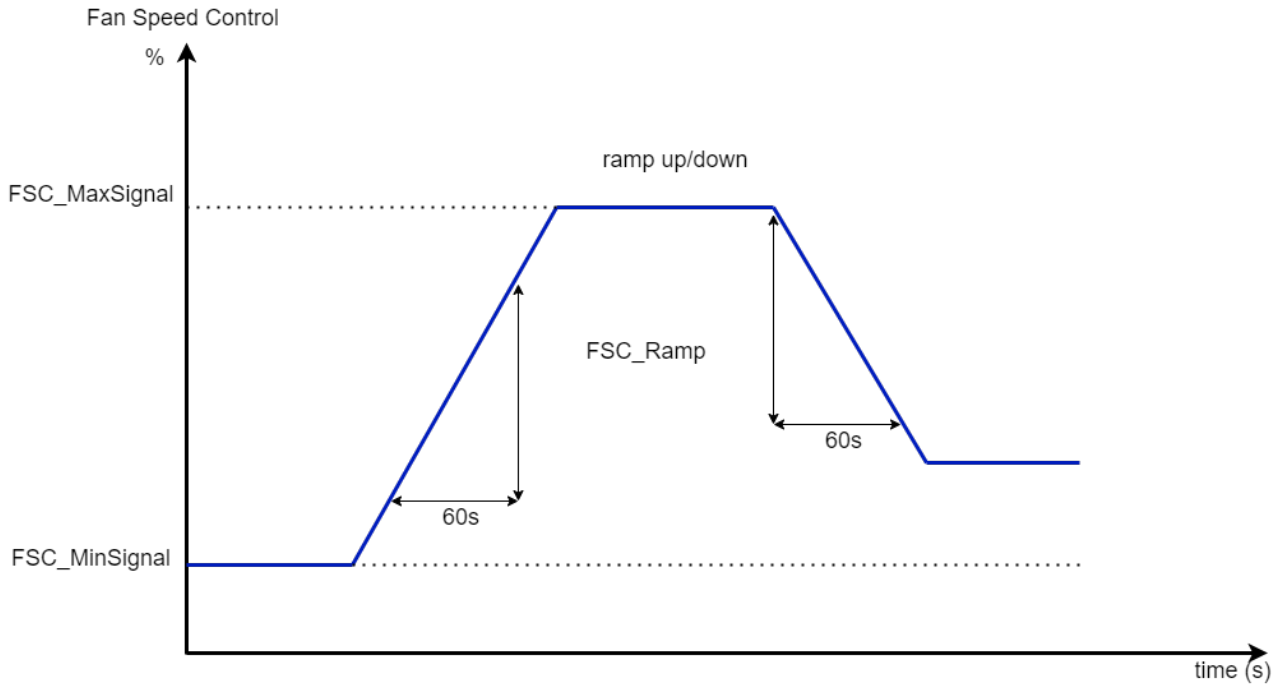


Figure 56. Ramp function for fan speed control

Setpoint Ramp-up/-down

On initial start-up, after the fan enables signal FNE to become true, the setpoint of the duct static pressure control will be ramped up, in Pa per minute, from zero to the value of the desired setpoint, as it is defined by the setpoints DischPressSpt & RetPressSpt. When during normal operation the setpoint of the duct static pressure is lowered, a ramp-down function will be effective. Both ramping-up and ramping-down are defined by the parameter DSP_PressSptRamp, as shown in the next figure.

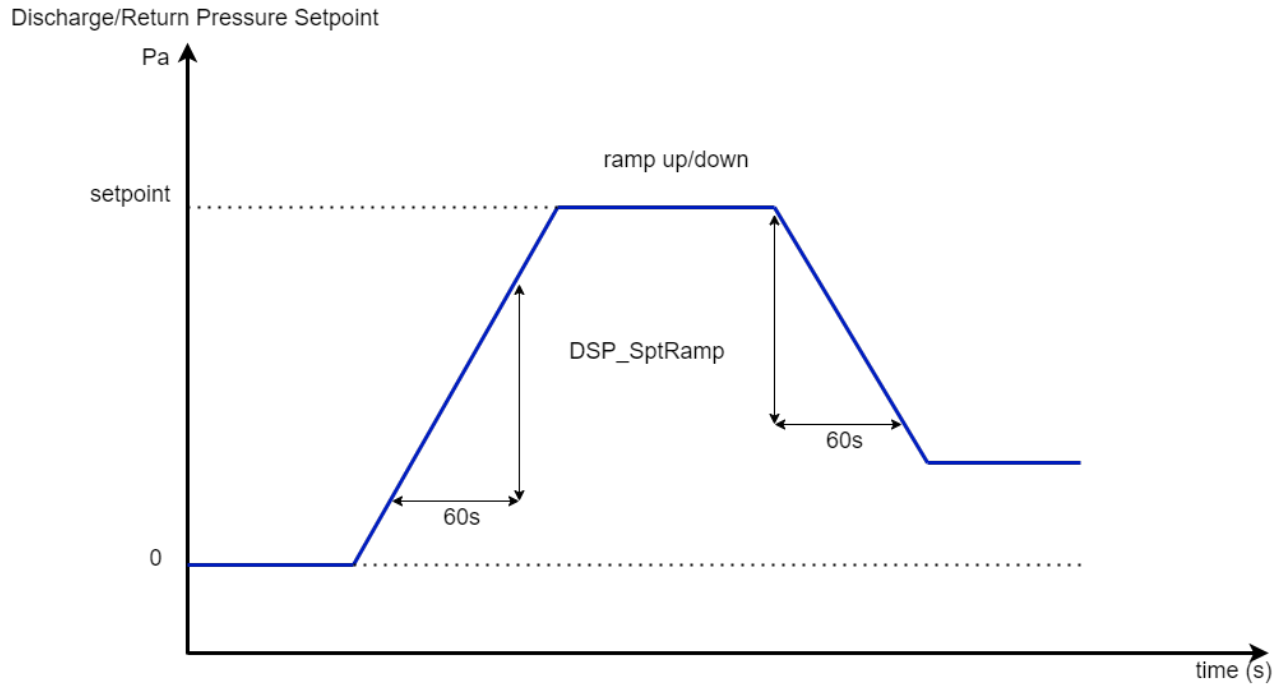


Figure 57. Ramp function for pressure setpoint

Duct Static Pressure Control

During plant modes 1 to 6, the duct static pressure control will be released as soon as the input FNE becomes true. The setpoint for the duct static pressure control is defined by the internal setpoints DischPressSpt & RetPressSpt, while the proportional band and integral time respectively are defined by the parameters DSP_PressDisP_band, DSP_PressRetP_band and DSP_PressDisI_time, DSP_PressRetI_time. For plant modes 1 to 3 both setpoints are reduced by multiplying with the same parameter for both DSP_NightReduce.

The next figure shows the internal control signal of the duct static pressure control in relation to its setpoint and proportional band.

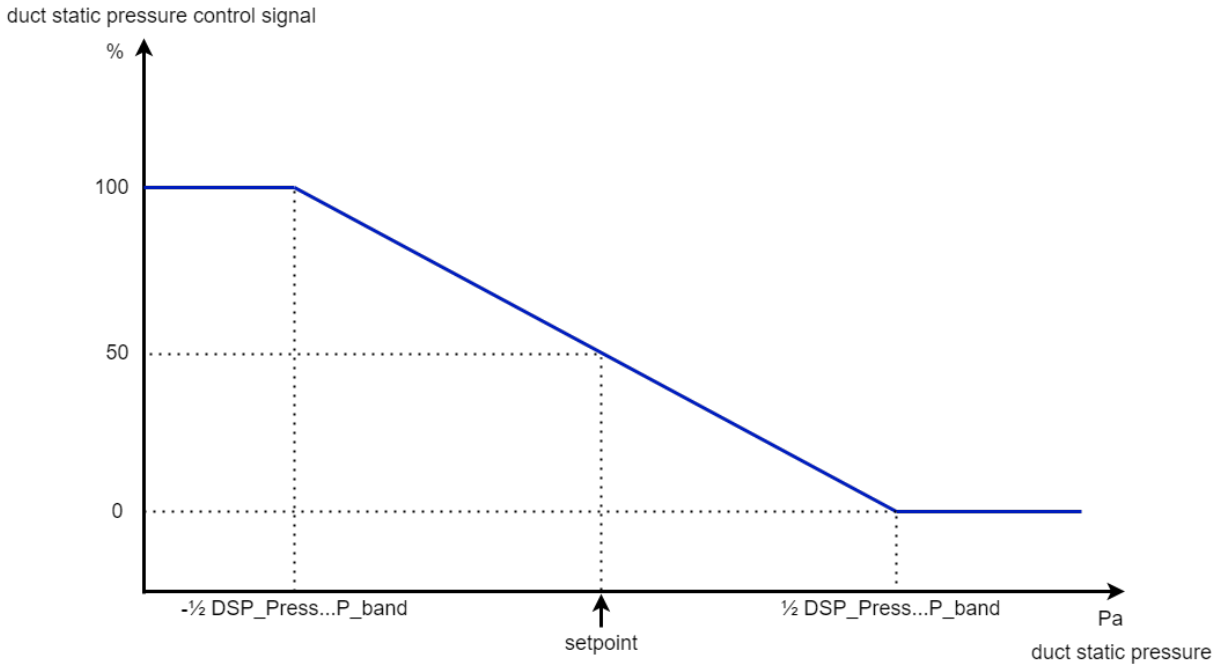


Figure 58. Static duct pressure control signal according to the static duct pressure

Fan Alarms

There is one alarm output available:

- Fan_BeltAlarm is an internal variable.

Note: The delay of the fan belt alarm is defined by the parameter FDP_BeltAlarmDelay. The fan belt alarm can be disabled by setting the value of parameter FDP_BeltAlarmDelay to the value of 0.

Manual/Automatic Reset

In case of an automatic reset (FSC_ManualReset=True), the fan outputs FansCmd, DischFan, and RetFan will stay energized when a fan belt alarm occurs. This is contrary to the manual reset selection (for MIX18 only, FSC_ManualReset=False), where these outputs will always be turned off.

To restart the fan after an alarm occurred, the panel-mounted reset button must be depressed. This button (connected to a Reset input) is brought into the software and further handled as the internal variable Reset.

If there is no push button fitted, parameter FSC_ManualReset should be set to the mode automatic reset.

Operation Switch

The purpose of the operation switch input is to allow for a controlled shut-down and restart procedure of the fan. Typically normally closed contacts from a local isolator next to the fan motor will be used. When the local isolator is switched off, the input OperationSwitch will be False and the outputs DischFan & RetFan and FansCmd will be de-energized. When the local isolator is switched back on and input OperationSwitch becomes True again, the plant can be restarted.

7.1.6 Humidifier

The Humidifier module provides modulating humidity control for humidifying and dehumidifying purposes. It can be used for water spray applications as well as for steam humidification. The humidity control is adjustable by parameter settings between minimum and maximum limits and is outside air compensated.

The module has inputs fo:

- room/return air RH (RAH);
- discharge air RH (DAH);
- maximum RH (Hygrostat);
- pump status or steam generator failure (HumidifierStatus);
- and fan differential pressure (FanDiffPressure).

The outputs are for:

- humidification (HUM);
- dehumidification (DEH);
- spray pump/steam generator enable (SPU);
- pump/steam generator failure;
- and related humidity high alarm (ALARM).

The module also generates signals as the internal variables HUM_Mode & DEH_Mode, which will be used by the Control module.

Humidity Control Delayed After the Fan Start

At the initial start of the air handling unit, all control functions assume normal temperature control before the humidity control is enabled. The humidity control will be delayed after the fan start (input FanDiffPressure must be true), e.g. 5 minutes, adjustable by parameter HUM_FanOnDelay. If the input FanDiffPressure becomes false during normal operation, the module will be blocked immediately. This feature reduces the risk of wet ducts on initial start-up and fan belt alarms.

Note: If the outside air temperature is below the value of parameter OAT_HighHum, only humidification can take place and if the outside air temperature is above the value of parameter OAT_LowDeh, only dehumidification is possible.

Four Types of Control

The module offers four different types of control, which can be selected by the control type parameter HumCtrlMode. The next table shows the control type possibilities.

HumCtrlMode	Type of humidity control
Comfort Zone (1 on LCD)	Room/return air relative humidity P-control with adjustable comfort zone
Return Hum (2 on LCD)	Room/return air relative humidity PI-control without comfort zone
Disch Abs Hum (3 on LCD)	Discharge air absolute humidity PI-control with room/return air relative humidity reset (cascade control)

HumCtrlMode	Type of humidity control
Constant Disch Abs Hum (4 on LCD)	Constant discharge air absolute humidity PI-control

Table 9. Types of humidity control

Room/Return Air Humidity P-control with Comfort Zone (HumCtrlMode as Comfort Zone [1])

The humidity control module works in a typical sequencing application: humidifying and dehumidifying with an adjustable comfort zone between. In this case, the module uses two separate proportional controllers with internally calculated setpoints for humidification and dehumidification, depending on the value of the internal setpoint HumSpt and the adjusted comfort zone, defined by parameter HUMDEH_ComfZone.

The value of the HumSpt can be compensated by the winter- or summer-compensation functions. The separate humidify and dehumidify P-controllers have their own P-band, respectively defined by parameters HUM_P_band and DEH_P_band.

Note: With this type of control (HumCtrlMode as Comfort Zone [1]), the integral times of RAH_I_time and HUMDEH_I_time will be used 0 for a control loop by the program of the module.

The next figure shows the calculated setpoints for the two controllers, and the adjusted comfort zone, which is symmetric around the HumSpt. The figure shows also the P-band for the humidify controller, totally shifted below its calculated setpoint, and the P-band for the dehumidify controller totally shifted above the calculated setpoint. For plant modes, 1 to 3 calculated comfort zone increases fourfold.

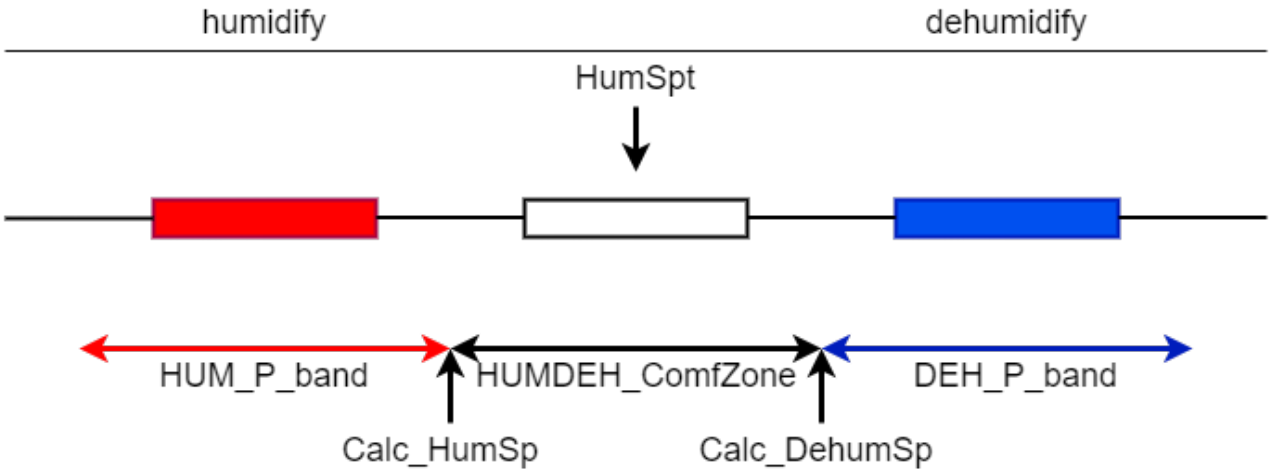


Figure 59. Humidification and dehumidification setpoints

The next figure shows the two P-controllers with shifted P-bands and calculated setpoints besides the adjusted comfort zone.

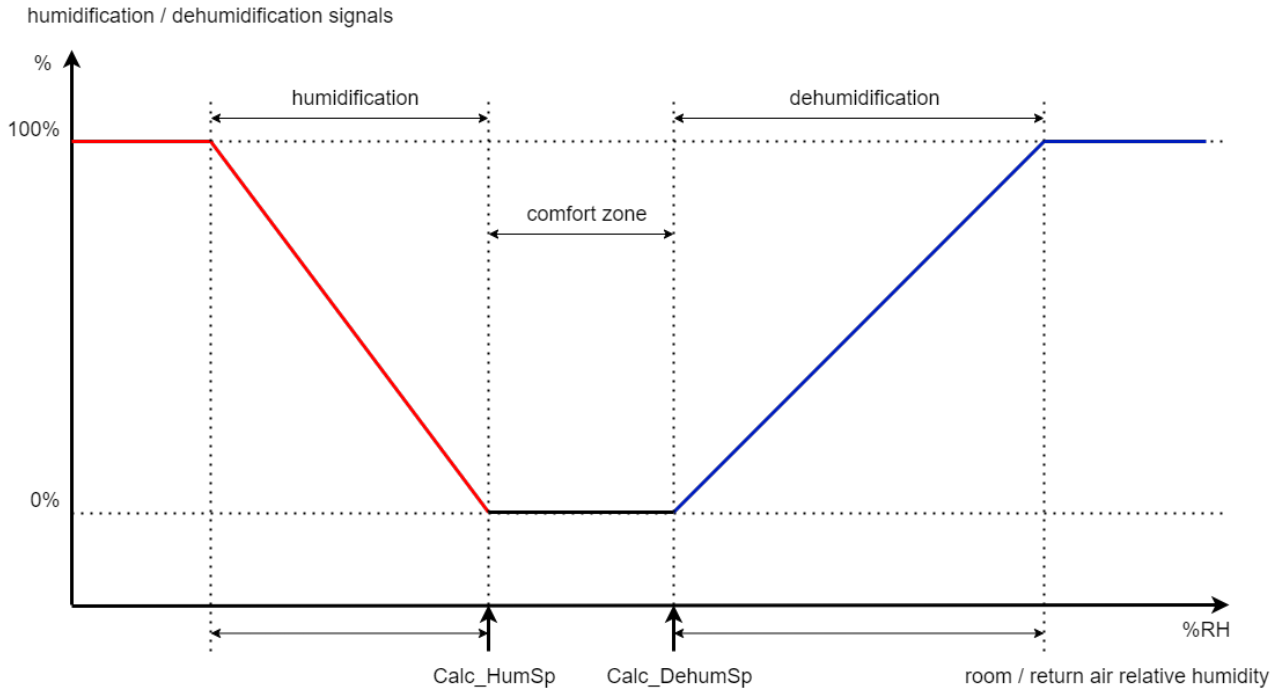


Figure 60. Humidification and dehumidification signals

Room/Return Air Humidity PI-control without Comfort Zone (HumCtrlMode as Return Hum [2])

The humidity control module works in a typical sequencing application: humidifying and dehumidifying. In this case, the module uses only two separate proportional and integral controllers with setpoints, defined by the value of the internal variable HumSpt. The value of the HumSpt can be compensated by the winter- or summer-compensation functions. The PI-controller has a proportional band, which is the summation of the P-bands respectively defined by parameters HUM_P_band and DEH_P_band. The integral time is defined by the parameter HUMDEH_I_time. The output control signal of this PI-controller sequences the module outputs HUM and DEH according to the rate of HUM_P_band and DEH_P_band, as shown in the figure of the Sequencing of the humidify and dehumidify output signals.

Discharge Air Absolute Humidity PI-control with RAH Setpoint Reset (HumCtrlMode as Disch Abs Hum [3])

The humidity control module works in a typical sequencing application: humidifying and dehumidifying. In this case, the module uses two proportional and integral controllers (master-slave or cascade control). The master PI controller is the room/return air relative humidity controller, which gets its setpoint from the internal variable HumSpt. The value of the HumSpt can be compensated by the winter- or summer-compensation functions. The master PI-controller P-band and I-time are respectively defined by the parameters RAH_P_band and RAH_I_time.

The slave PI-controller is the discharge air absolute humidity controller and its setpoint can be reset by the master PI-controller between the minimum and maximum values, as defined by the respective parameters DAH_LowAbsHumSpt and DAH_HighAbsHumSpt

Note: This type of control (HumCtrlMode as Disch Abs Hum [3]) is only possible when the absolute humidity of the discharge air has to be controlled because relative humidity will always be affected by undesired temperature fluctuations within the supply duct. So, the input DAH of the module must be connected to an absolute humidity sensor to calculate the absolute humidity from the temperature and the relative humidity in the supply air duct.

The next figure shows the relation between the room/return air humidity deviation and the discharge air absolute humidity setpoint.

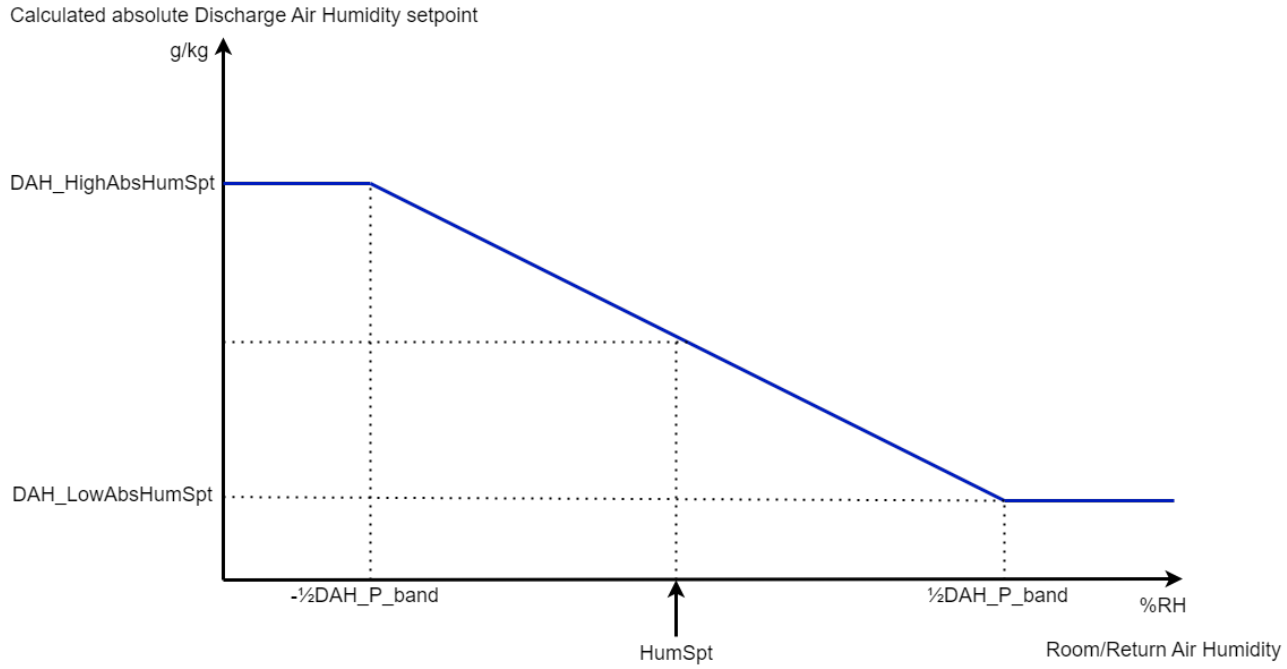


Figure 61. Absolute discharge air humidity setpoint according to the room/return air humidity

The slave PI-controller has a proportional band, which is the summation of the P-bands, respectively defined by the parameters HUM_P_band and DEH_P_band.

The output control signal of this slave PI-controller sequences the module outputs HUM and DEH according to the rate of HUM_P_band and DEH_P_band, as shown in the figure of the Sequencing of the humidify and dehumidify output signals.

Constant Discharge Air Absolute Humidity PI-control (HumCtrlMode as Constant Disch Abs Hum [4])

The humidity control module works in a typical sequencing application: humidifying and dehumidifying. In this case, the module uses two PI-controllers with setpoints, defined by the value of the internal variable HumSpt (this variable should be called in this case, e.g.: AbsDAHSpt). The PI-controller has a proportional band, which is the summation of the P-bands respectively defined by parameters HUM_P_band and DEH_P_band. The integral time is defined by the parameter HUMDEH_I_time. The output control signal of this PI-controller sequences the module outputs HUM and DEH according to the rate of HUM_P_band and DEH_P_band, as shown in the figure of the Sequencing of the humidify and dehumidify output signals.

Note: This type of control (HumCtrlMode as Constant Disch Abs Hum [4]) is only possible when the absolute humidity of the discharge air has to be controlled because relative humidity will always be affected by undesired temperature fluctuations within the supply

duct. So, the input DAH of the module must be connected to an absolute humidity sensor to calculate the absolute humidity from the temperature and the relative humidity in the supply air duct.

Sequencing of Humidify and Dehumidify Output Signals

When HumCtrlMode equals 2, 3 or 4, the output signals for humidify and dehumidify will be sequenced according to the rate of values of HUM_P_band and DEH_P_band.

Example: Assuming that HUM_P_band=25 (100/25=4) and DEH_P_band=16.67 (100/16.67=6), then the internal signal of 0-100% is divided for humidification (40%) and dehumidification (60%).

The next figure shows the sequencing of the output signals of HUM and DEH.

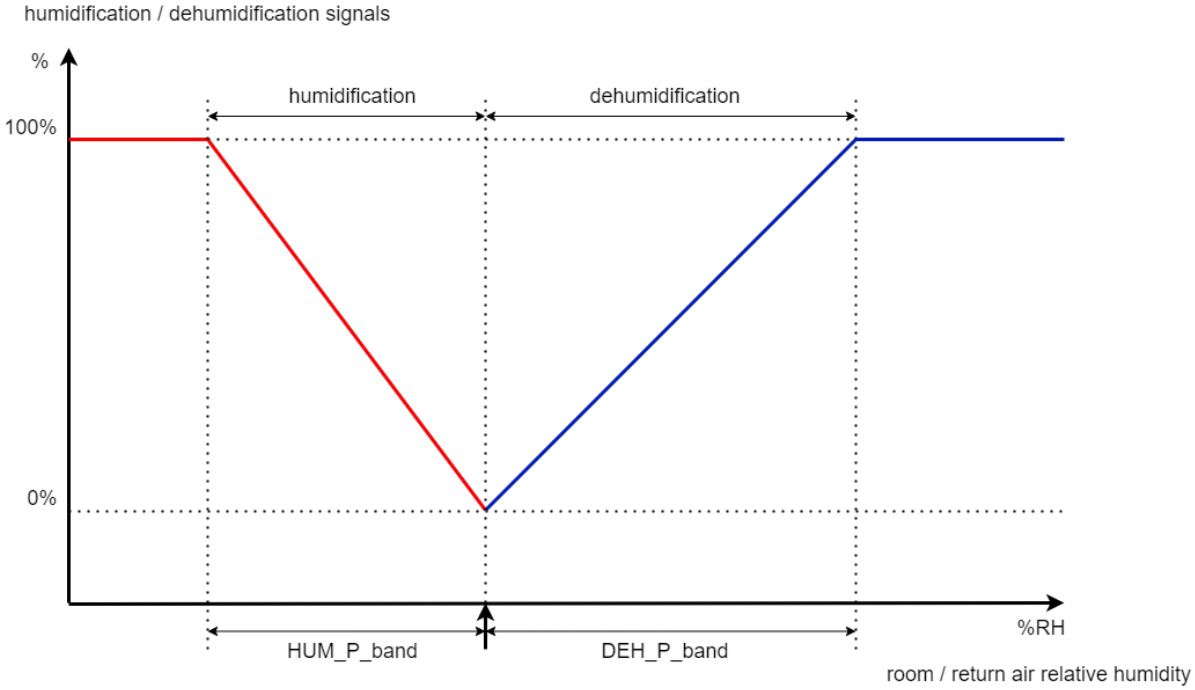


Figure 62. Sequencing of the output signal of humidification and dehumidification

Winter and Summer Compensation of the RH-setpoint

The calculated room RH setpoint is outside air compensated, defined by parameters WC_LowOAT, WC_HighOAT, SC_LowOAT, and SC_HighOAT, and limited between minimum and maximum values, defined by parameters RAH_MinHumSpt and RAH_MaxHumSpt, as shown in the next figure.

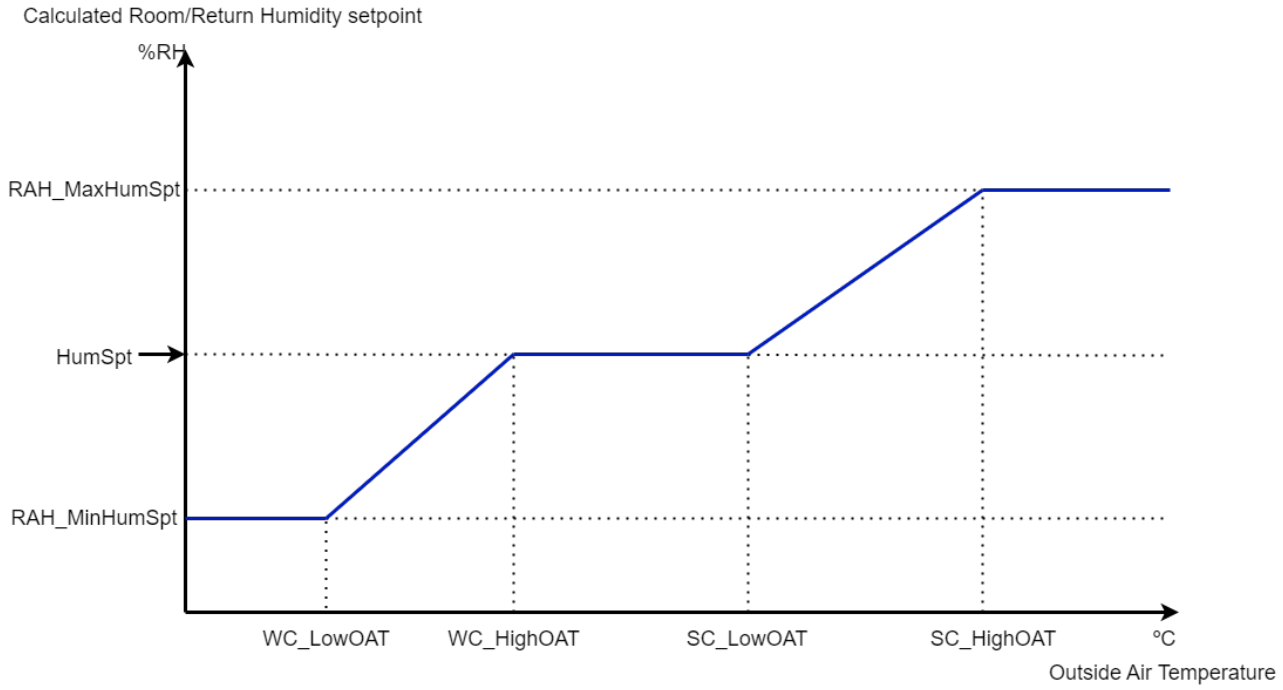


Figure 63. Room/return humidity setpoint according to the outside air temperature

Maximum RH Limitation of Discharge Air

To prevent the risk of wet ducts, the relative humidity is limited to a value, defined by the parameter DAH_MaxSpt. Depending on the maximum RH setpoint and the DAH_P_band the internal maximum RH control signal varies from 0 to 100%, as shown in the next figure.

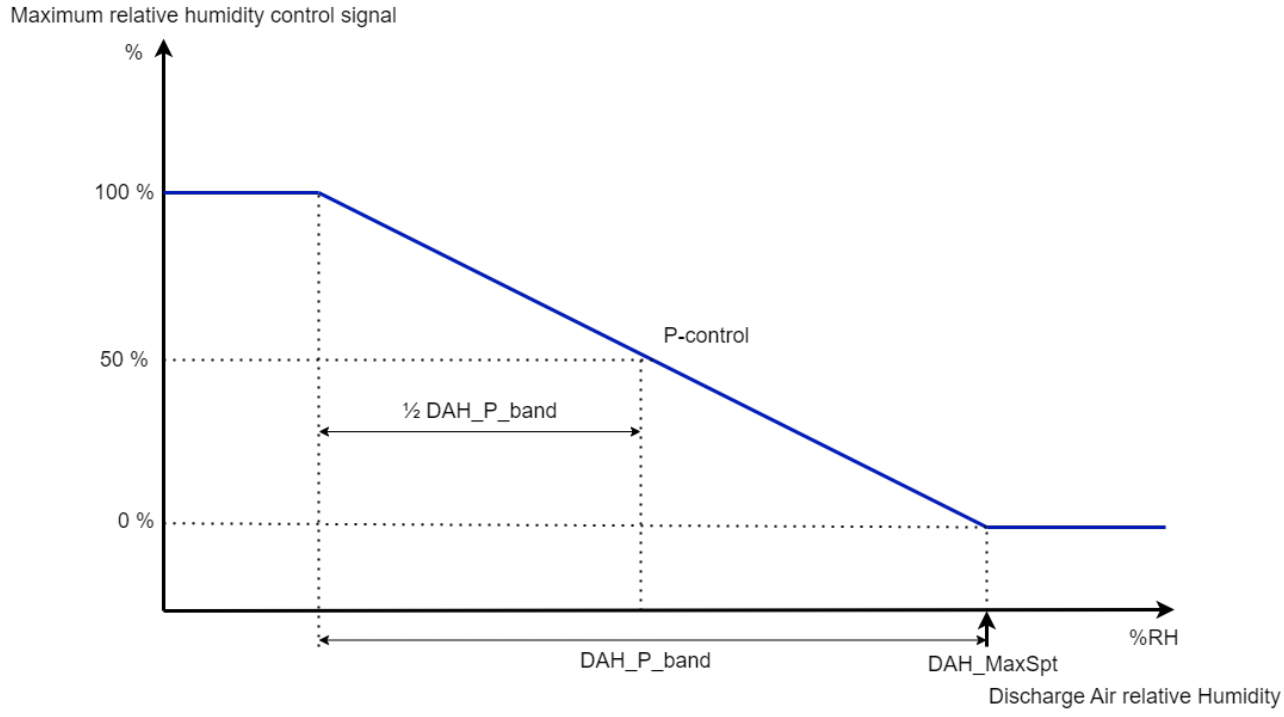


Figure 64. Maximum relative humidity control signal

A plausibility check is executed on the Hygrostat input, which means that only in the case of humidifying the Hygrostat input is monitored. When the maximum discharge air limit

for hygrostat becomes true (=1), it will override the room RH control and generate an alarm at the internal variable HumHighAlarm.

Ramp-up of Control Signals

Both output signals, respectively for humidification HUM and dehumidification DEH will be ramped up in percents per minute, defined by parameters HUM_RampUp and DEH_RampUp, to ensure stable and efficient RH control, as shown in the next figure.

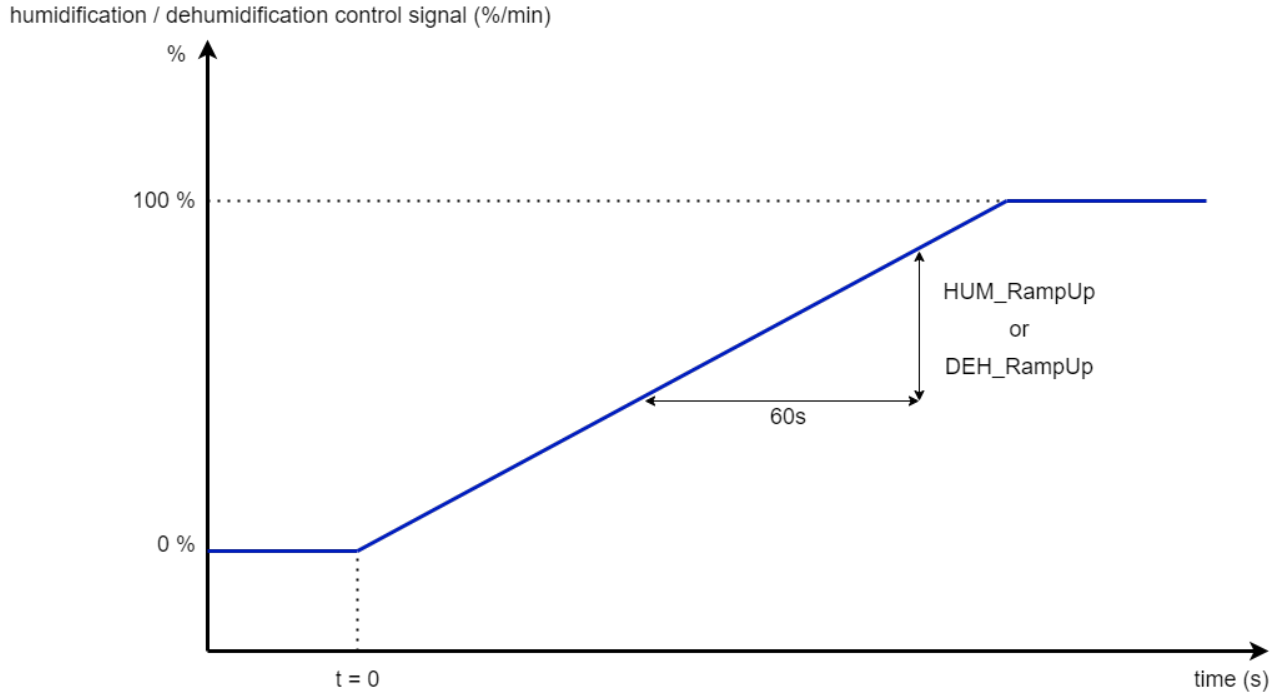


Figure 65. Ramp function for relative humidity control

Note: To speed up the ramp functions, the respective parameters HUM_RampUp and/or DEH_RampUp can be set to the value of 100. In that case, the signal will be raised at 100% per minute and this is faster than the runtime of the actuator that is normally used.

Selection of Spray Pump or Steam Humidifier

The selection of a spray pump or steam humidifier is done with the parameter HumidifierMode. If HumidifierMode is Water Humidifier [1], then the output SPU will switch on and off the spray pump, while in this case the output HUM most of the time will not be used. If HumidifierMode is Steam Humidifier [2], then the output SPU will act as a steam-generator enable signal, which is set to on during normal operation and will only be disabled in case of a failure.

Humidifier Status

In case the humidifier/pump status is connected, fail-to-command and humidifier/pump-off alarms are generated. The input can also be defined as a failure monitoring input for humidifier failure. When a failure or pump-off alarm occurs, the humidification output control signal (HUM) is directly set to 0%. Only in case of a failure, additionally, the output SPU is also switched off.

Selection of Alarms, Humidifier Status, or a Fail-to-command Alarm

With the parameter HUM_StatusAlarmDelay, it is possible to select different kinds of alarms for internal input Humidifier Status, as shown in the next table.

HUM_StatusAlarmDelay setting	Alarm output behavior
> 1	The status is monitored and differentiated off-alarms are generated, after the delay of parameter HUM_StatusAlarmDelay
= 1 (default)	The status input will be handled as a failure input without delay (a logic 1 at the input means a failure condition)
= 0	No monitoring is done and no alarms are generated
< 0	The status is monitored and a fail-to-command alarm is generated at the on-alarm output, after the (absolute) time of the delay, defined by parameter HUM_StatusAlarmDelay

Table 10. Alarm output behavior

Hygrostat

The internal variable Hygrostat generates an alarm when during humidification the relative humidity in the duct has exceeded the set level as defined by the maximum humidity. During dehumidification, the maximum hygrostat can cause an alarm because of the high relative humidity in the supply duct. In this case, the variable Hygrostat will not generate an alarm. The alarm will be reset automatically as soon as the Hygrostat input returns to normal. In the case of an HumHighAlarm, the humidification control signal is set to 0% and the spray pump/humidifier enable is set to off.

7.1.7 Economizer

The Economizer module generates two coded signals as internal variables (EnthalpyOverride and AbsHumOverride) with a possible value of False or True, representing the absolute humidity comparison and the enthalpy comparison between outside air and return air conditions. The internal variables are used by the Control module.

The economizer mode override reduces the load on a cooling coil by selecting an airflow to be cooled that has the least total heat (enthalpy). Enthalpy is a measure of the total (latent and sensible) heat content of the air. Whenever outside air enthalpy is greater than return air enthalpy, only a minimum amount of outside air is allowed to enter the fan system. Enthalpy and absolute humidity control are based on a calculation using dry-bulb temperature and relative humidity.

During the warm season of the year, the total heat content of both return air and outside air is used to determine which source of air is the most efficient to use for cooling.

The module uses internal inputs for:

- return air temperature (RAT);
- return air relative humidity (RAH);
- outside air temperature (OAT);
- and outside air relative humidity (OAH).

General

The module uses 4 internal inputs, respectively return air temperature and humidity and outside air temperature and humidity. With the information from these sensors, the module calculates the enthalpy values as well as the absolute humidity values of the return and outside air. With the parameter AtmPressure, the atmospheric pressure can be adjusted and used in the calculation method. The module provides two internal digital outputs as override outputs, which are used in the Control module.

Enthalpy Comparison for Economizer Functions

During the warm season of the year, the total heat content of both return air and outside air is used to determine which source of air is the most efficient to use. Whenever outside air enthalpy is greater than the return air enthalpy, only a minimum amount of outside air is allowed to enter the air handling unit during the cooling season. The economizer mode is based on a comparison between the total heat content or the absolute humidity and uses dry-bulb temperature and relative humidity sensors for the calculation of the total heat. With this economizer function, the cooling load can be reduced during warm periods of the year. The difference in enthalpy values must have a higher value than the value of parameter EnthalpyDiff before the override function becomes active.

Absolute Humidity Comparison for Dehumidification Function

Absolute humidity comparison is used for dehumidification purposes in the Control module. The difference in absolute humidity values must have a higher value than the value of the parameter AbsHumDiff before the override function becomes active.

Switch-over Delays

Both enthalpy- and absolute humidity overrides are activated after a delay defined by the parameter SwitchoverDel. This delay prevents fast and often switching between both condition situations.

Note: It is recommended to set the parameter SwitchoverDel (by default, 300 s) to a rather high value, to prevent chattered switching.

7.1.8 Control

The module provides the control for an air handling unit. The module has inputs for:

- outside air temperature (OAT);
- discharge air temperature (DAT);
- room or return air temperature (RAT);
- air quality signal (CO2);
- manual operation switch condition (OS), and
- fan enable signal (FNE).

The respective outputs are signals for:

- heating control (HTS);
- cooling control (CCS);
- energy recovery control (ERS);
- dampers control (DMS),
- fan speed control (FSC);

- dehumidification (DEH);
- air quality controls (CO_2).

The following internal inputs are included in this module:

- PlantMode (from Plant Schedule);
- TempSpt;
- CO2Setpoint;
- DEH_Mode (from Humidifier);
- HUM_Mode (from Humidifier);
- AbsHumOverride (Economizer);
- EnthalpyOverride (from Economizer).

Start Procedure on Initial Start-up to Prevent Frost Alarm

On the initial start of the air handling unit, this application prevents start-up problems and provides frost protection. The heating coil valve and dampers must be in the right positions before the fan(s) can start and all other output signals are released to their normal positions.

To assure a smooth start-up at low outside air temperatures (below OAT_FrostProt), the AHU with mixed air dampers starts on forced recirculation during the time of parameter MAD_RecircTimeStart, when the Plant Mode changes to occupied period or extended operation (4 or 5).

If during start-up the outside air temperature is below the value of parameter OAT_FrostProt, the AHU discharge air temperature setpoint will be raised temporarily by a value, defined by parameter DAT_SptRamp, as soon as the period of forced recirculation has elapsed. Then, it will be ramped down again to its normal setpoint within the time defined by parameter DAT_SptDecTime.

Integral Time Enable Delay After Start-up

After the AHU has been started, both temperature controllers for a room and discharge air temperature will be only proportional controllers during the time, defined by parameter DAT_I_time. After this I-enable delay, the integral functions will start with a value of 0, to assure a smooth start-up.

Types of Temperature Control

Depending on the setting of the parameter TempCtrlMode, the module offers different types of control:

- Cascade control (TempCtrlMode as Cascade Temp [1])

Discharge air temperature control with room temperature reset, using both room temperature and discharge air temperature sensors, providing the possibility of PI-control on the room temperature as well as on the discharge air temperature. Sequencing of the output signals for heating, dampers/energy recovery, and cooling. Fan speed is controlled, based on the room temperature deviation with pressure holding priority if present. CO_2 (air quality) override on the dampers and/or fan speed.

- Constant DAT control (TempCtrlMode as Constant Disch Temp [2])

Constant discharge air temperature control, using only the discharge air temperature sensor, provides PI control on the discharge air temperature. CO_2 (air quality) override on the dampers and/or fan speed.

- Comfort zone cascade control (TempCtrlMode as Comfort Zone Temp [3])

Discharge air temperature control with room temperature reset and room temperature comfort zone, using both room temperature and discharge air temperature sensors. The P-controller for the room temperature control sequences the output signals of the dampers/energy recovery equipment within the comfort zone. Outside the comfort zone, setpoint adjustments will be provided for the discharge air temperature and fan speed. For plant modes 1 to 3 calculated comfort zone increases fourfold. Two PI controllers for discharge air temperature control. Fan speed can be controlled, based on the room temperature deviation with pressure holding priority if present. CO_2 (air quality) override on the dampers and/or fan speed.

Cascade Control (TempCtrlMode as Cascade Temp [1])

Discharge air temperature and fan speed control with room/return air temperature reset. For this function, it is absolutely necessary to have a temperature sensor connected to the input ReturnTemp of the module. The discharge air temperature setpoint and fan speed are shifted by the room temperature deviation. The room temperature setpoint can be reset by the OAT because of the summer compensation. The application uses one room temperature PI-controller to sequence the discharge air temperature setpoint and the fan speed.

The P-band and the I-time of the room temperature controller are respectively defined by parameters RT_P_band and RT_I_time. The P-band and I-time of the discharge air temperature controller are respectively defined by parameters DAT_P_band and DAT_I_time. The discharge air temperature setpoint is always limited by the low and high-temperature values as defined by parameters DAT_LowSetpoint and DAT_HighSetpoint.

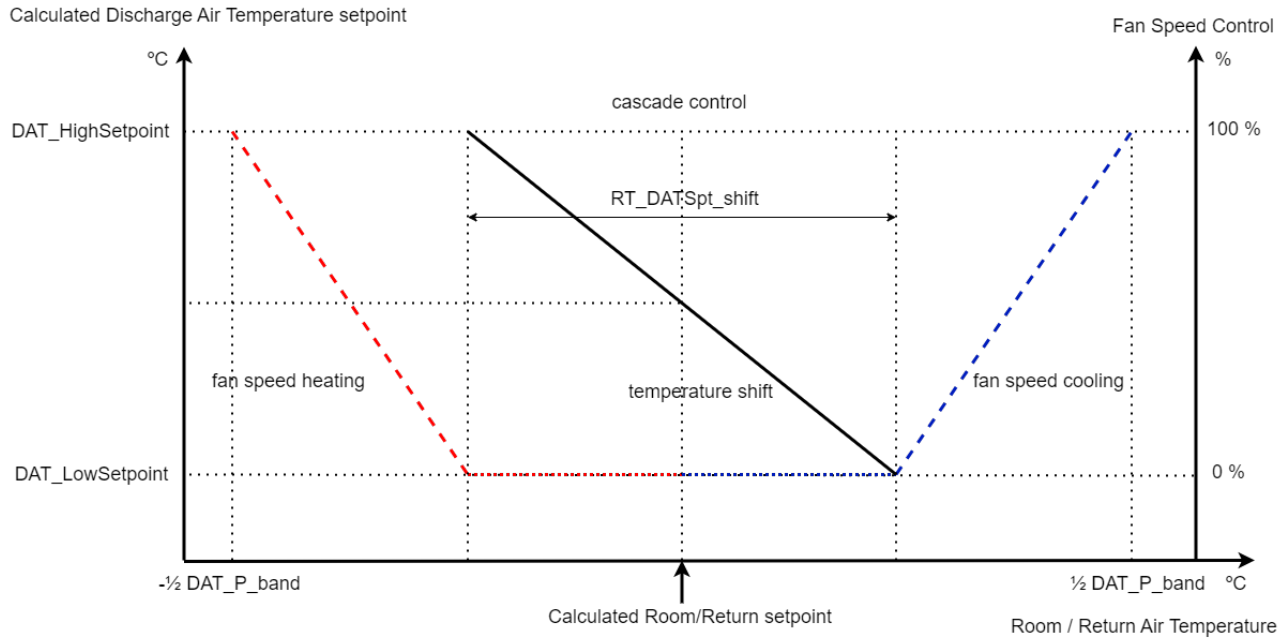


Figure 66. Cascade control

Note: With this cascade control (TempCtrlMode=1), it is also possible to create a control type, based on room temperature with min. and max. limitation of the discharge air temperature. To do so, the room temperature P-band (RT_P_band) can be increased to a

value of e.g. 4K (value 25), while the I-time (RT_I_time) must be set to a rather high value, e.g. 3600 seconds (value 0.03). Now there is no fixed relation between the discharge air temperature and the room temperature deviation, only the DAT limits will always be effective.

Sequential Control of the Output Signals, Based on Discharge Air Temperature

In the Control module, the sequencing of all output control signals can be defined. The respective output signals are destined for heater, dampers/energy recovery, and cooler. With the parameters DAT_-Start - DAT_-End the start- and the end-point of each output signal can be adjusted, based on discharge air temperature control, as shown in the next example.

Note: The end-point parameters must always have a higher value than the start-point parameters. If both start- and end-point parameters are set to 0, then that particular sequence function will be inactive.

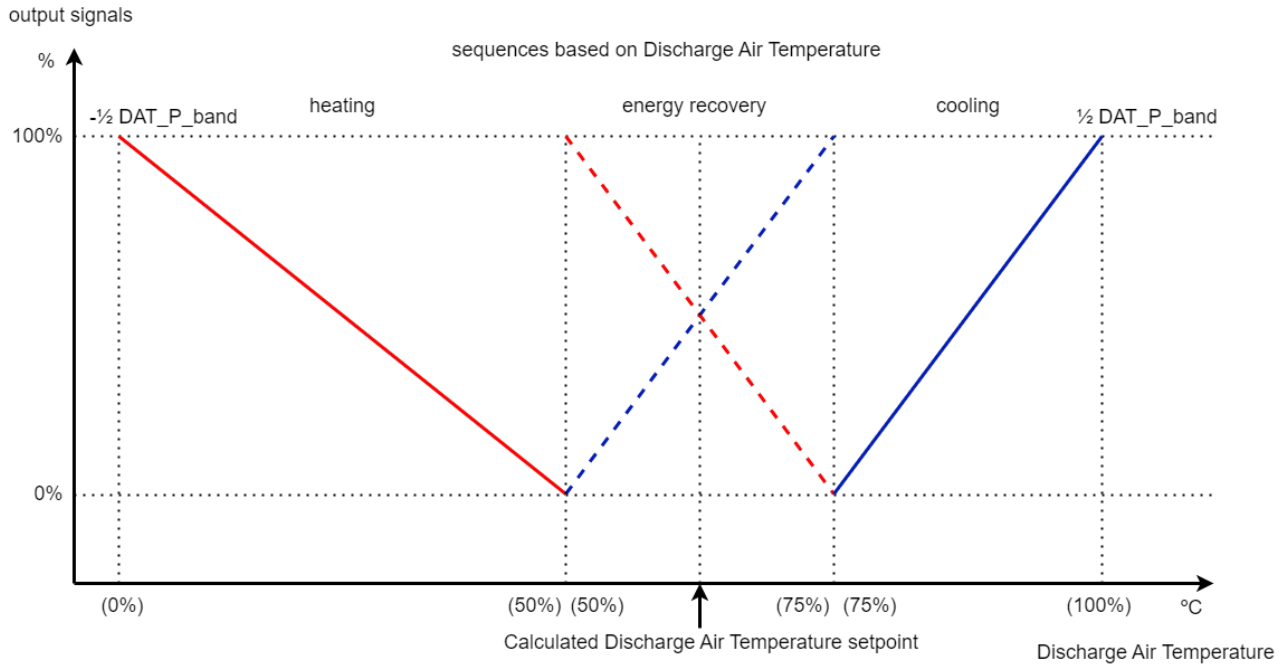


Figure 67. Sequences based on discharge air temperature

Constant DAT Control (TempCtrlMode as Constant Disch Temp [2])

Constant discharge air temperature control with winter compensation, but without room temperature reset. The discharge air temperature is PI-controlled with a setpoint, defined by the value of the internal variable TempSpt. In this case, the minimum and maximum discharge air temperature limits, respectively defined by parameters DAT_LowSetpoint and DAT_HighSetpoint, will be ignored.

Comfort Zone Cascade Control (TempCtrlMode as Comfort Zone Temp [3])

Control with room / return temperature reset and room/return temperature comfort zone, providing:

- cascade control of DAT;
- fan speed control;
- sequence control of dampers or energy recovery equipment.

Cascade Control of DAT

Discharge air temperature control with room/return temperature reset and comfort zone. For this function, it is absolutely necessary to have a temperature sensor connected to the input ReturnTemp of the module. The discharge air temperature setpoint and fan speed are shifted by the room temperature deviation. The room temperature setpoint can be reset by the OAT because of the summer compensation.

The application uses one P-controller for the room temperature, to reset the setpoints for the two discharge air temperature PI-controllers (heating and cooling) in order to sequence the discharge air temperature and the fan speed, with respect to the comfort zone between, which is defined by parameter RT_ComfortZone. For Plant Mode 1 to 3 calculated comfort zone increases fourfold. With parameter RT_DATSpt_shift the respective end-points of the discharge air temperature setpoint-shifting for heating and cooling can be adjusted.

The P-band for the room temperature P-controller is defined by the parameter RT_P_band.

Note: With this type of control, the integral time for the room temperature controller, defined by parameter RT_I_time, will be automatically set to 0.

The next figure shows the comfort zone around the compensated room temperature setpoint and the way the room temperature deviation affects the discharge air temperature setpoint.

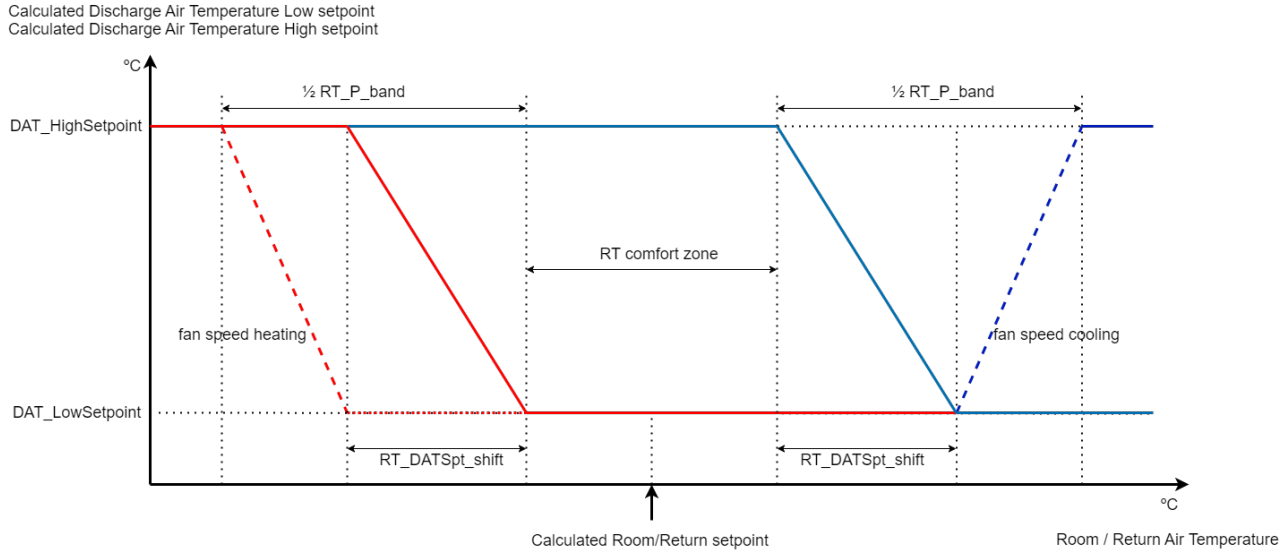


Figure 68. Discharge air temperature setpoint according to room/return air temperature

The P-band and I-time adjustments for both discharge air temperature controllers are respectively defined by parameters DAT_P_band and DAT_I_time. Each controller uses ½DAT_P_band as P-band.

The discharge air temperature setpoint is always limited by the low and high-temperature values as defined by the parameters DAT_LowSetpoint and DAT_HighSetpoint.

Minimum Discharge Air Temperature Control

The minimum discharge air temperature controller uses the discharge air temperature sequencer, defined by the parameters DAT_-Start-DAT_-End. The output signals of the sequencer are used to override the heating, dampers/energy recovery, and cooling control signals.

When the discharge air temperature becomes below the minimum discharge air temperature setpoint, defined by DAT_LoSpt, then the cooling coil will be closed first, the energy recovery control signal will be raised/dampers will be closed and finally, the heating coil will be opened. This prevents the opening of the heating coil, while the dampers are still open. (The room temperature controller controls dampers). The next figure shows the minimum discharge air temperature override sequencer.

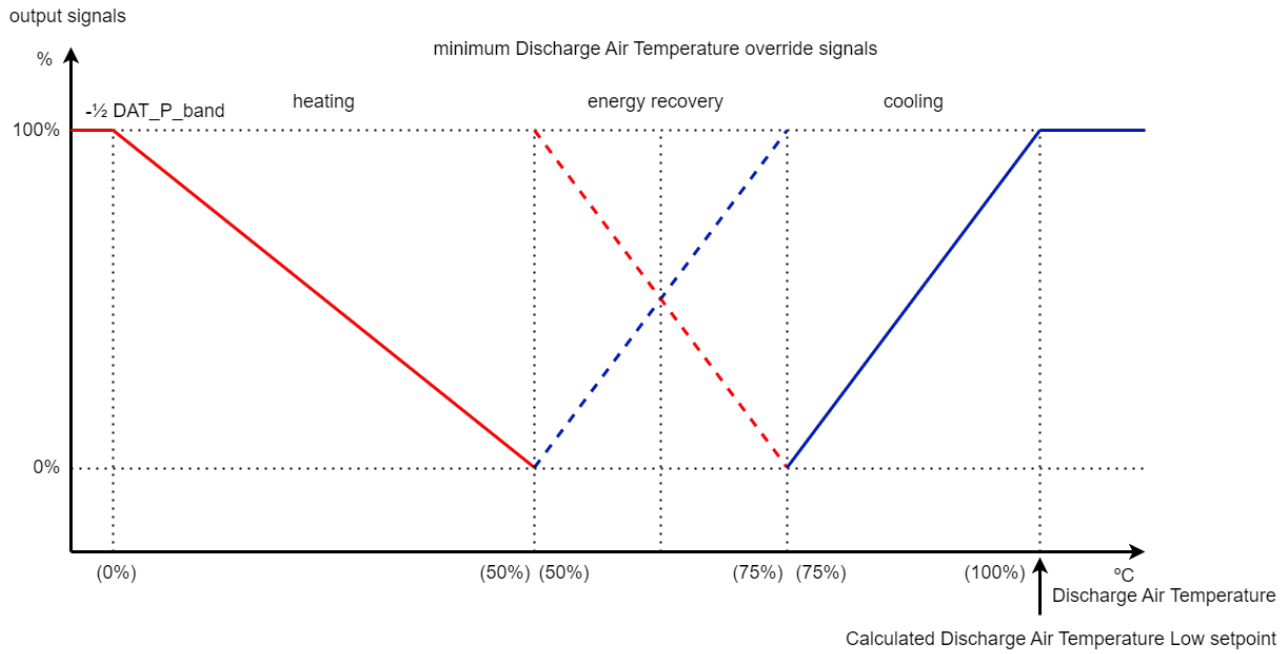


Figure 69. Minimum discharge air temperature override sequencer

Note: The end-point parameters must always have a higher value than the start-point parameters. If both start- and end-point parameters are set to 0, then that particular sequence function will be inactive.

Maximum Discharge Air Temperature Control

The maximum discharge air temperature controller uses the discharge air temperature sequencer, defined by the parameters DAT_-Start-DAT_-End. The output signals of the sequencer are used to override the heating, dampers/energy recovery, and cooling control signals.

When the discharge air temperature becomes above the maximum discharge air temperature setpoint, defined by DAT_HiSpt, then the heating coil will be closed first, the damper control signal will be raised/energy recovery will be closed and finally, the cooling coil will be opened. This prevents the opening of the cooling coil, while the dampers are not fully open. (The room temperature controller controls dampers). The next figure shows the maximum discharge air temperature override sequencer.

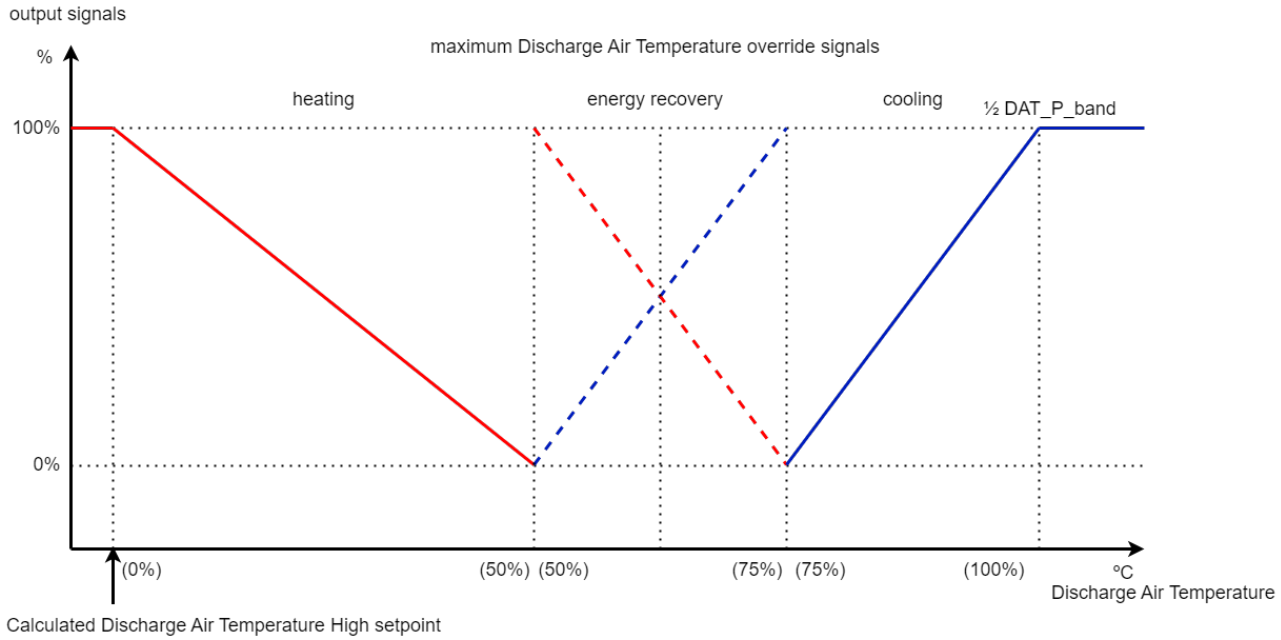


Figure 70. Maximum discharge air temperature override sequencer

Note: The end-point parameters must always have a higher value than the start-point parameters. If both start- and end-point parameters are set to 0, then that particular sequence function will be inactive.

Fan Speed Control

Control of fan speed, based on room/return temperature comfort zone (TempCtrlMode=3). For this function, it is absolutely necessary to have a temperature sensor connected to the input ReturnTemp of the module. The fan speed output signal FSC can be controlled between 0-100%, depending on the room/return temperature deviation outside the comfort zone, as defined by parameter RT_ComfortZone. For Plant Mode 1 to 3 calculated comfort zone increases fourfold.

With parameter RT_DATSpt_shift the respective start-point of the fan speed sequencing for heating and cooling can be defined, as a partition of the half-proportional band RT_P_band of the room temperature P-control.

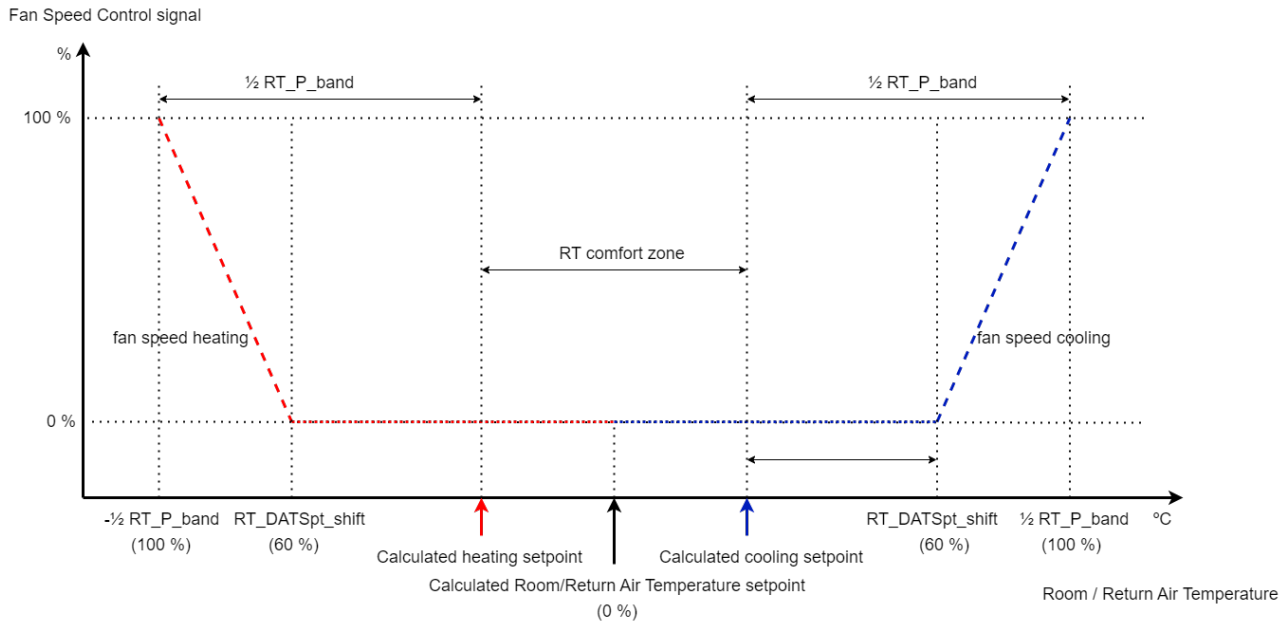


Figure 71. Fan speed control

Sequence Control of Dampers or Energy Recovery Equipment

Dampers or energy recovery control, based on the room/return temperature within the comfort zone (TempCtrlMode=3). The dampers or the energy recovery equipment will be controlled in sequence, based on the room temperature deviation and within the room temperature comfort zone. These sequencing actions are almost non-energy consuming but will help to keep the room temperature at the desired room temperature setpoint. The respective start- and end-point parameters for the dampers/energy recovery output signal are DAT_EnergyRecStart and DAT_EnergyRecEnd.

Notes:

- The Y-signal of the dampers or energy recovery can be reversed by the economizer function, which was selected by the parameter EconomizerMode.
- The end-point parameters must always have a higher value than the start-point parameters. If both start- and end-point parameters are set to 0, then that particular sequence function will be inactive.

The next figure shows the respective sequences within the room temperature comfort zone.

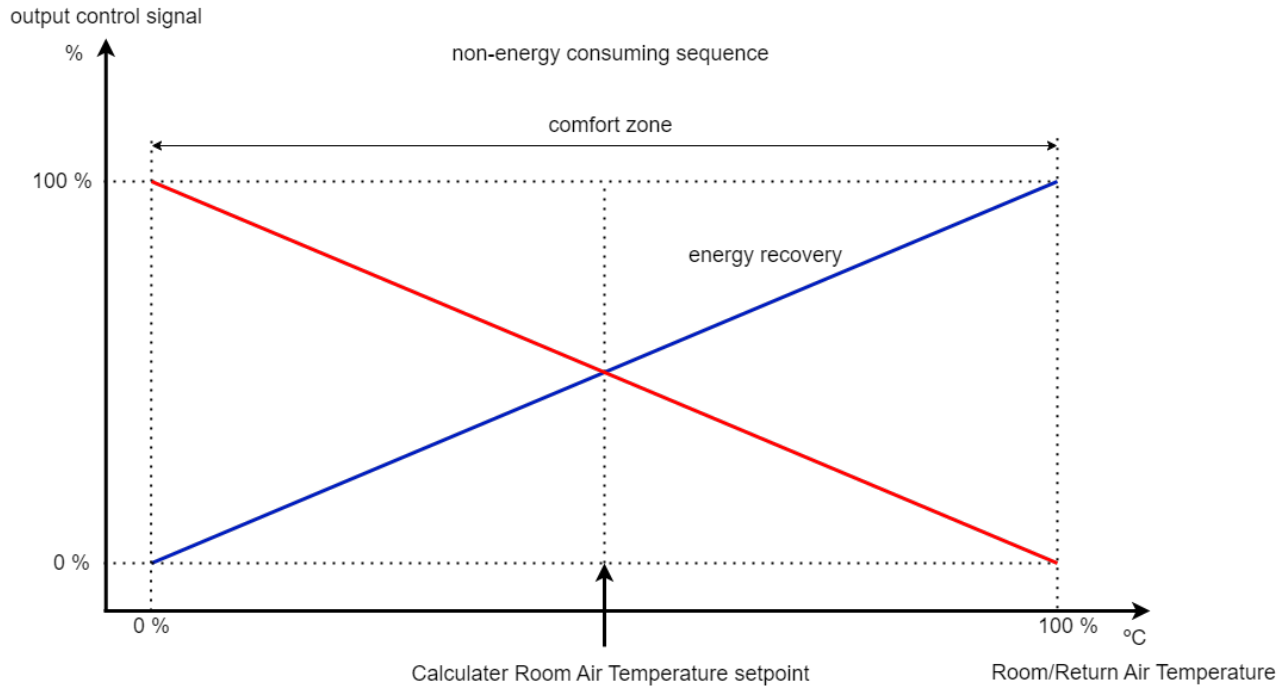


Figure 72. Non-energy consuming sequence

Fan Speed Control Based on Humidification

The fan speed can be increased when the humidification control signal increases from 0-100%. With parameters HUM_FanStart and HUM_FanEnd the sequence start- and end-point can be defined for the fan speed, as shown in the next figure.

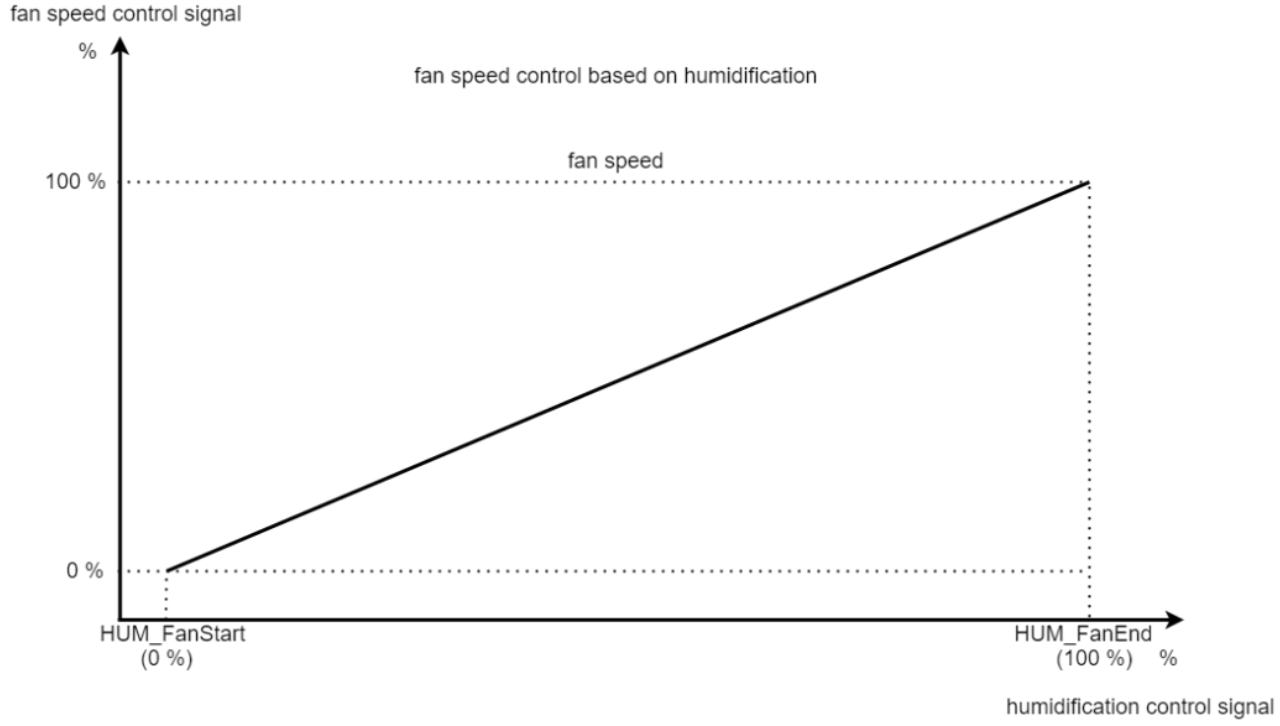


Figure 73. Fan speed control based on humidification

Note: If the sequence start- and end-point parameter values are both set to 0, then this function will be inactive.

The variables HUM_Mode, and DEH_Mode, which are generated by the humidifier module, transmit the coded signal for humidification, dehumidification, or none of both

(within the adjustable room relative humidity comfort zone of the humidifier module) into this Control module.

Code	HUM_Mode	DEH_Mode
0	No humidification	No dehumidification
1	1=humidify	1=dehumidify

Table 11. Humidification and dehumidification modes

Intelligent Dehumidification Control

For this intelligent dehumidification control, it is recommended to make use of the economizer module, which provides the enthalpy override and the absolute humidity comparison. The parameter EconomizerMode, which defines the economizer function, should be set to the value 2, in this case. When the DEH_Mode coded signal from the humidity control. equals a value of 1, then dehumidification is active. Depending on the comparison of the absolute humidity between outside air and return/room air, it is possible to dehumidify by sequencing the dampers, the fan speed, and the cooling coil valve.

- Sequencing Output Signals, Based on Dehumidification (OAx < RAx)

With the parameters DEH_-Start - DEH_-End the start- and end-point of the output control signals of the dampers, fan speed, and cooling can be adjusted based on dehumidification as shown in the next figure. It depends on the actual control signal, which controls mode, temperature, or dehumidify, and controls the respective output signals.

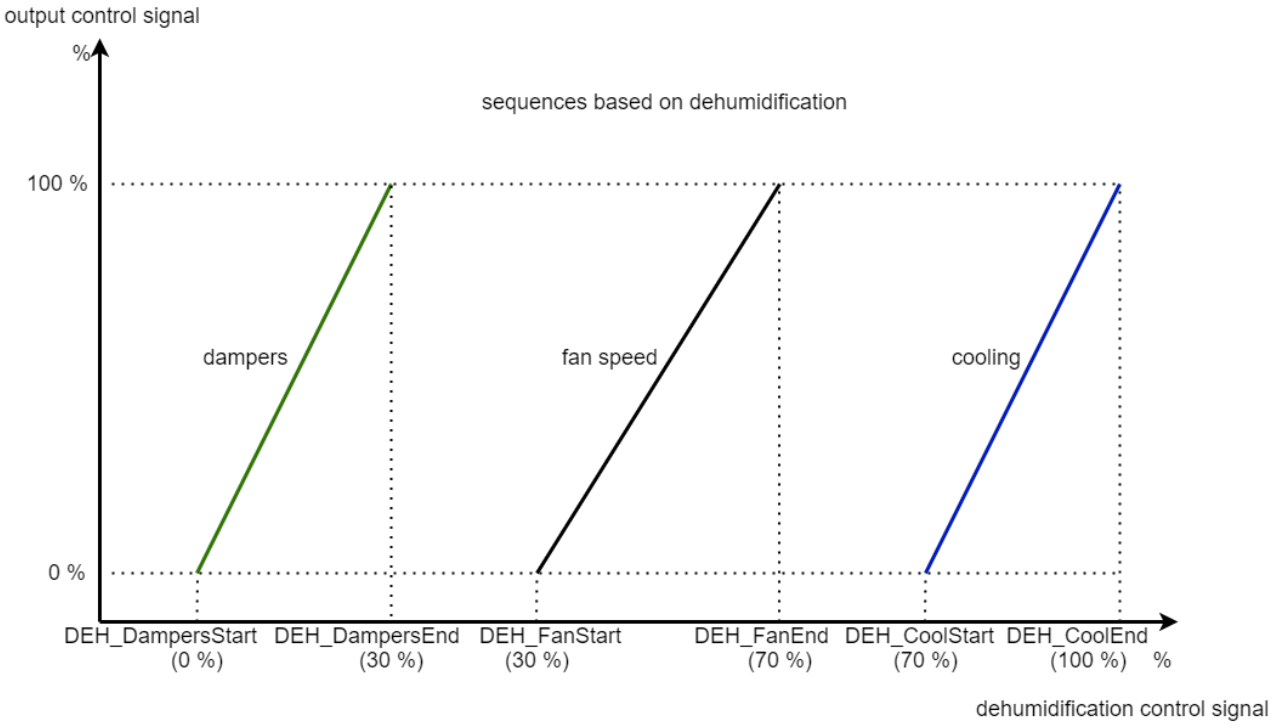


Figure 74. Sequences based on dehumidification

The respective sequencing parameters can be adjusted with gaps or overlaps as desired, as shown in the next example.

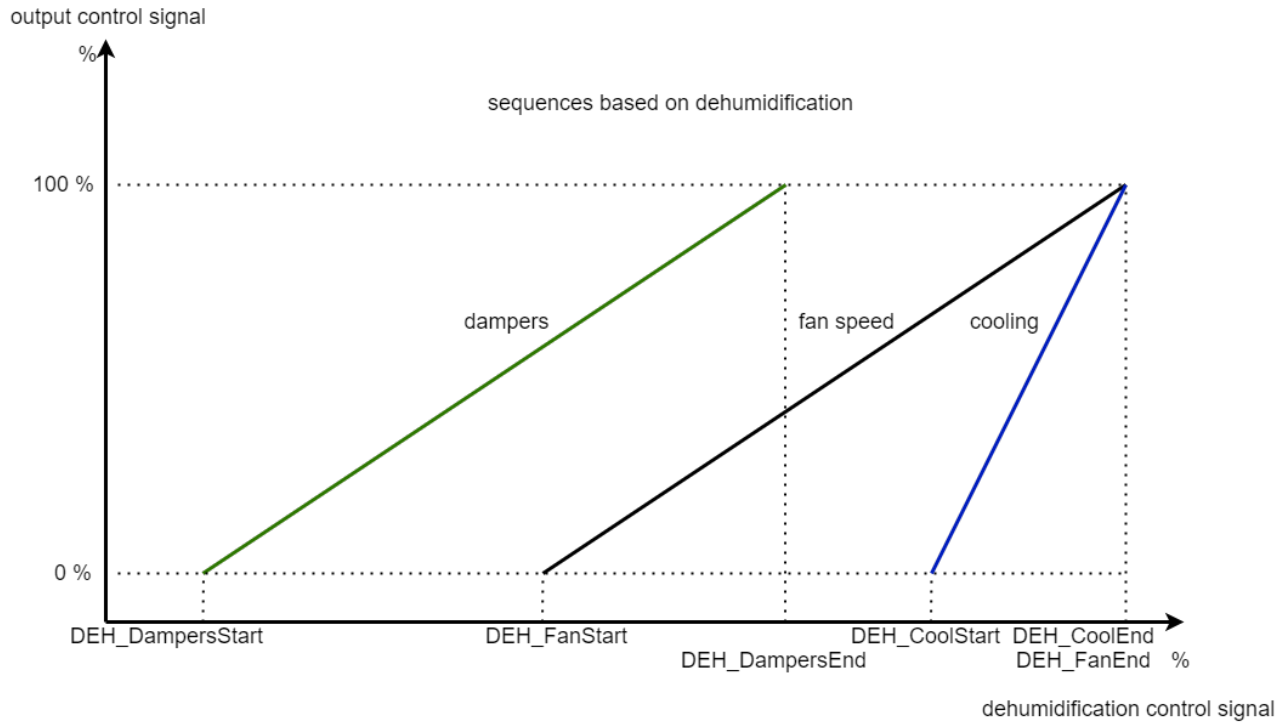


Figure 75. Sequences based on dehumidification

Note: The end-point parameters must always have a higher value than the start-point parameters. If both start- and end-point parameters of a sequence are set to 0, then that particular sequence function will be inactive.

- Sequencing Output Signals, Based on Dehumidification (OAx > RAx)

Only in the case of parameter EconomizerMode having a value of 2 and if the outside air absolute humidity is higher than the room/return air absolute humidity, the fan speed and cooling coil sequence will be interchanged. So, the cooling coil valve will be modulated to the open position first and will then be sequenced with the fan speed. The start-point value of the cooling coil valve sequence is automatically set to 0% and the end-point value of the fan speed sequence at 100%. The sequence start- and end-points of the dampers are automatically set to 0, which means that damper sequencing is eliminated in this case. See the next figure.

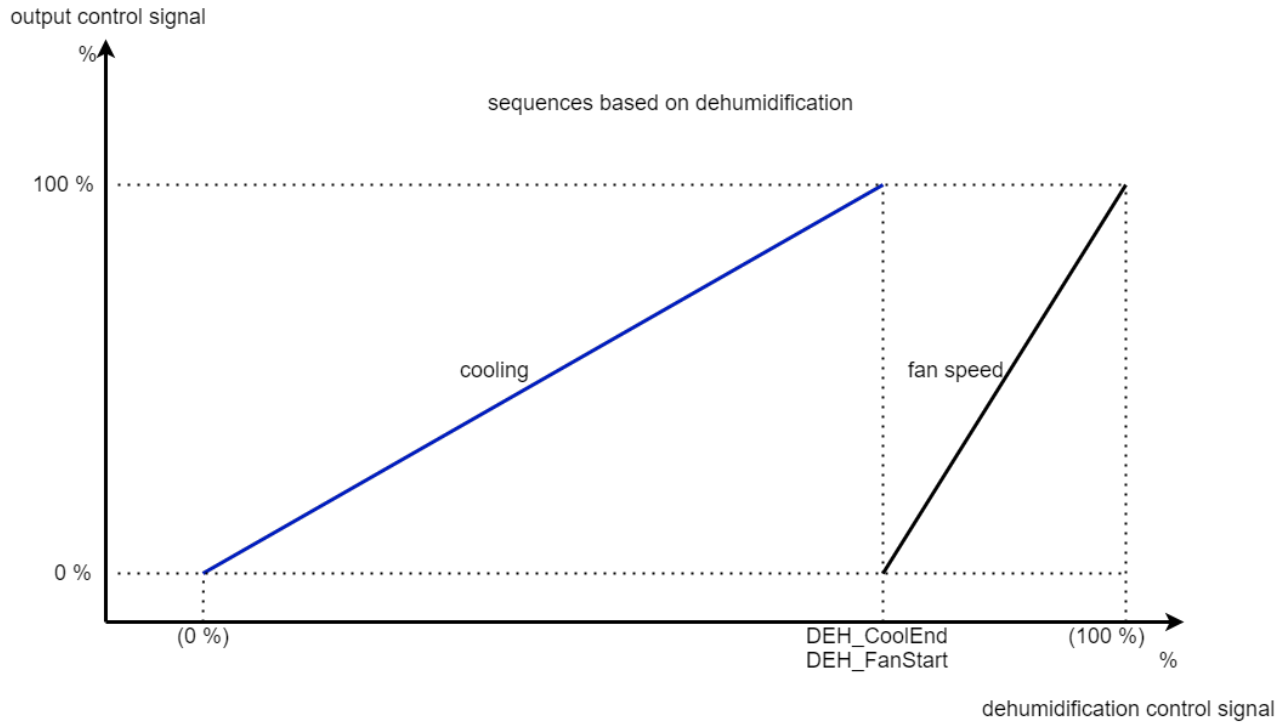


Figure 76. Sequences based on dehumidification

CO_2 Air Quality Override on Dampers and Fan Speed

If a CO_2 sensor is connected to the input CO_2 (for mixing dampers version), the air quality setpoint and the proportional band for the internal proportional controller can be defined in parts per million (ppm) by means of the respective parameters CO2Setpoint and CO2_P_band.

The total proportional band is shifted below the setpoint, as shown in the next figure.

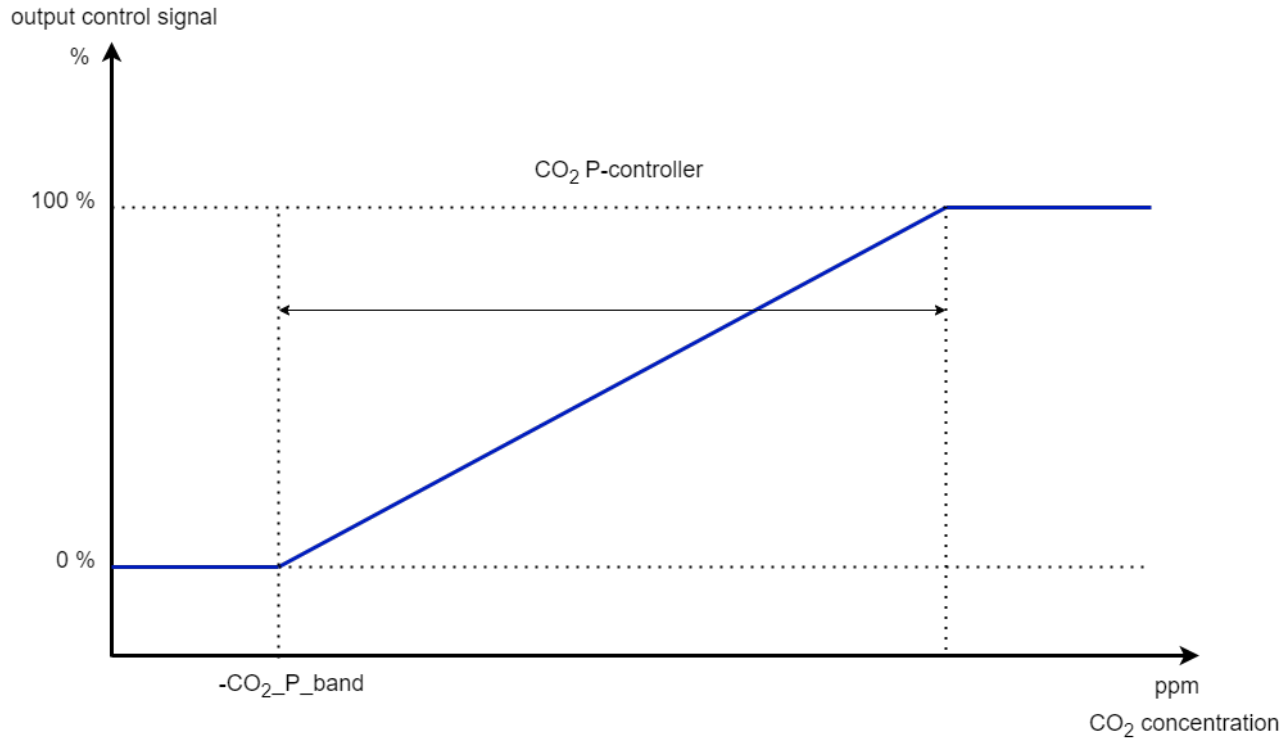


Figure 77. CO2 output control signal

The fan speed of a variable speed fan can be increased, when the air quality controller produces a signal that is higher than the start point of the CO_2 override, defined by parameters CO2_-Start - CO2_-End. The next figure shows the air quality override function on the internal damper and fan speed control signal, which are finally maximized with other respective internal signals.

Note: The end-point parameters must always have a higher value than the start-point parameters. If both start- and end-point parameters of a sequence are set to 0, then that particular sequence function will be inactive.

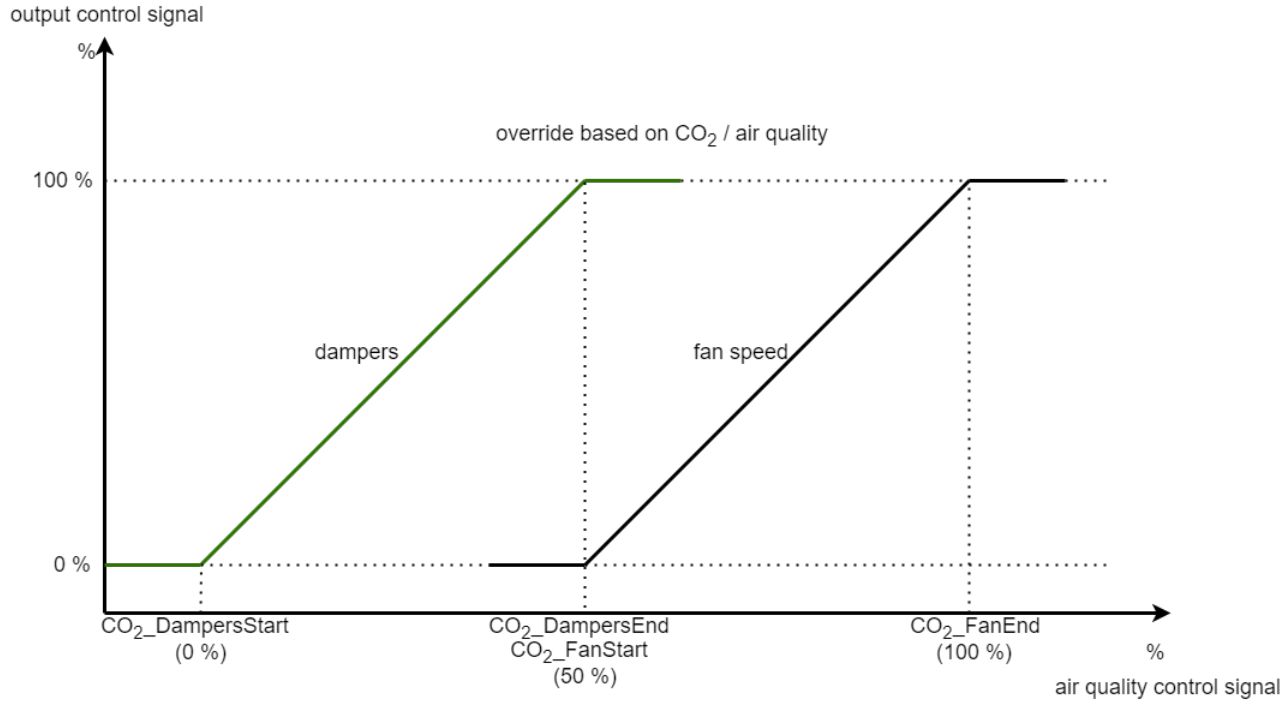


Figure 78. Override based on CO2/air quality

Tip: Sometimes, the air quality device is an active controller with its own proportional band and setpoint, providing an output signal from 0-1 V or 0-10 V between a certain span, e.g., between 800-1000 ppm. This signal has to be converted into a 0-100 % signal in order to connect it to the input CO_2. When the device measures the air quality, equal to the minimum value, then the input signal will be 0%. If air quality goes bad, up to the maximum value, the signal will raise up to 100 %.

WARNING: To disable the internal CO_2 controller in this case, the value of parameter CO2Setpoint (=setpoint air quality control) must be set to 0.

Winter Compensation of Discharge Air Temperature Setpoint

To eliminate increased building transmission losses and from the comfort point of view (during the winter period), a higher discharge air temperature is desired. With decreasing outside temperatures, the discharge air temperature setpoint is reset as defined by parameters WC_DischStartComp and WC_DischEndComp.

The winter compensation raise is defined by parameter WC_DischSptRaise, shifting the discharge air temperature setpoint and the respective minimum and maximum limit setpoints DAT_LowSetpoint and DAT_HighSetpoint upwards.

Note: If parameter WC_DischSptRaise is set to 0, there will be no winter compensation.

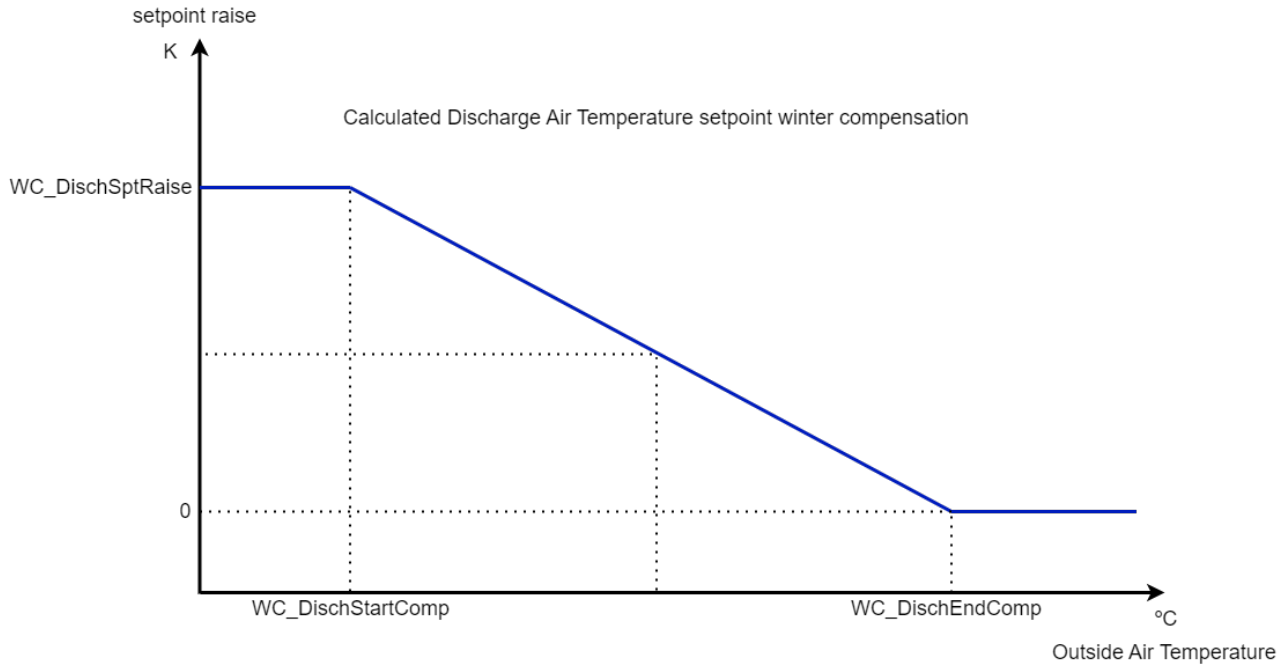


Figure 79. Calculated discharge air temperature setpoint winter compensation

Summer Compensation of Room Temperature Setpoint

To save cooling energy during the summer period, the room temperature setpoint is reset by the outside air temperature, defined by parameters SC_RoomStartComp and SC_RoomEndComp.

The summer compensation setpoint raise is defined by the parameter SC_RoomSptRaise.

Note: If SC_RoomSptRaise is set to the value of 0, there will be no summer compensation.

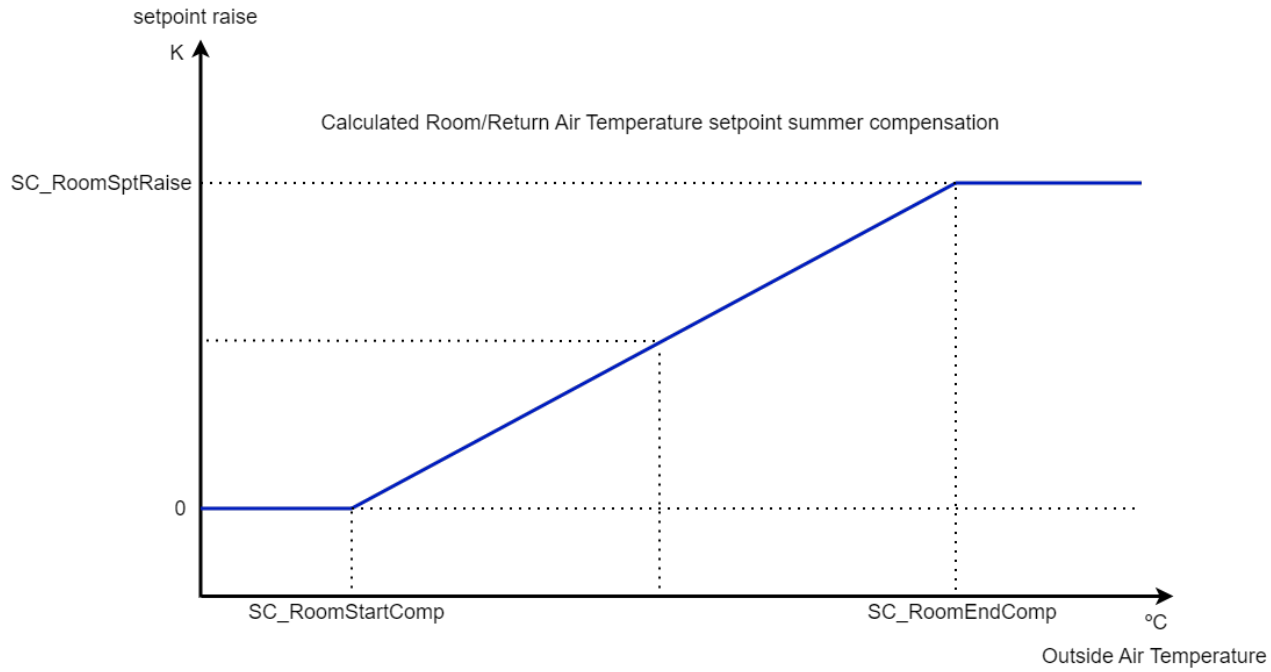


Figure 80. Calculated room/return air temperature setpoint summer compensation

Blocking Heater Valve During the Summer Season

During the summer, it is possible to block the heater valve at high outside air temperatures to save energy on the heating load. With parameter OAT_HeaterLimit the temperature can be defined, above which the heater valve will stay closed.

Note: The HTS output signal will be automatically released again if the coded signal DEH_Mode equals the value of 1 (dehumidification is needed).

Blocking the Cooling Valve During the Winter Season

During the winter, it is possible to block the cooling valve at low outside air temperatures to save energy on the cooling load. With parameter OAT_CoolerLimit the temperature can be defined, below which the cooling valve will stay closed.

Frost Protection/Frost Recovery After Frost Alarm

When the frost protection via the plant mode signal becomes active, the following action occurs:

- all output control signals, except HTS, are set to 0%.
- the HTS output is set to a value of 100%.

Frost protection actions are normally performed in the respective output modules.

When the frost failure has been reset, there will be a start-up procedure at low outside air temperatures. To prevent frost alarm again, the AHU with mixed air dampers will start on forced recirculation, followed by a temporarily raised discharge air temperature setpoint, which will be slowly decremented to the value of its normal discharge air temperature setpoint. The ramp-down time can be adjusted by the parameter DAT_SptDecTime. During forced recirculation, the DMS output signal will have a value of -1, which forces the damper output module to ignore its own minimum damper position adjustment.

Economizer Function for Cooling-load Savings

To save energy on cooling load, the energy recovery control signal can be reversed and the mixed air damper control can be reversed or set to a minimum position. With the parameter EconomizerMode, the economizer function of the energy recovery or dampers can be selected for different operating situations, as shown in the next table.

EconomizerMode setting	Economizer function
None (0 on LCD)	Function disabled
Eco Return Temp (1 on LCD)	If the room temperature is above the value of the calculated room temperature setpoint and the outside air temperature is higher than the return temperature behind exhaust fan (return air temperature sensor connected to input ReturnTemp).
Eco Enthalpy (2 on LCD)	On absolute humidity and/or enthalpy override from the economizer module: DAMPERS: a) if HUM_Mode=1 and EnthalpyOverride=1, then the damper control signal will be reversed;

EconomizerMode setting	Economizer function
	b) if HUM_Mode=0 or DEH_Mode=1 and AbsHumOverride=1, then the damper control signal are set to minimum; c) if HUM_Mode=0 or DEH_Mode=2 and AbsHumOverride=0 and EnthalpyOverride=1, the damper control signal will be reversed. ENERGY RECOVERY: a) if EnthalpyOverride=1, then the energy recovery control signal will be reversed.

Table 12. Economizer function for cooling-load settings

Note: Air quality control override (CO_2) has a higher priority than the economizer function.

Economizer Mode

The economizer mode override signals from the economizer module or the temperature comparison (inside the Control module itself) are used, for instance, to reverse the mixed air damper control signal and energy recovery control signal. In the case of absolute humidity comparison during dehumidification, the action of the mixed air dampers is inverted. With the parameter EconomizerMode, the economizer function is selectable.

Abs. X comparison	Code	Enthalpy comparison	Code
OAx < RAx	0	OA enthalpy < RA enthalpy	0
OAx > RAx	1	OA enthalpy > RA enthalpy	1

Table 13. Economizer mode

7.2 Advanced Parameters

Advanced parameters of the AHU application are available directly from the iSMA Tool/iC Tool. After connecting and logging into the AAC20 controller, expand the device tree, and go to the Logic folder. In the expanded Logic folder, there are the main functional modules.

Functional modules (except Inputs, Outputs, Setpoints, Config, and General) contain the Parameters subfolder with advanced parameters allowing to tune the AHU application to the air handling unit to be controlled. Most of air handling unit types do not require changes and can remain with default values (changed only in special implementations). The parameters that may typically be needed for fine-tuning are usually loop settings, but in many cases the defaults are sufficient.

Note: Advanced parameters are available only from the iSMA Tool/iC Tool level - they are not available from the LCD, web server or via BACnet IP/Modbus TCP.

The list of available advanced parameters divided into functional modules:

7.2.1 Dampers

No	Name	Description	Range	Default	Units
1	MAT_MinSetpoint	Minimum mixed air temperature setpoint	0-50	10	°C
2	MAT_MaxSetpoint	Maximum mixed air temperature setpoint	0-50	15	°C
3	MAT_P_band	Mixed air temperature control P-band	0.01-100	10	100/K
4	MAD_RunTime	Actuator damper runtime - 0=disable runtime	0-1440	150	sec
5	OAT_MinSetpoint	Minimum outside air temperature	-50-50	-10	°C
6	OAT_MaxSetpoint	Maximum outside air temperature	-50-50	10	°C
7	DMS_MinPosition	Minimum damper position	0-100	20	%
8	DMS_MaxPosition	Maximum damper position	0-100	100	%
9	DMS_StartRatioControl	Ratio damper control signal sequence start	0-100	0	%
10	DMS_StopRatioControl	Ratio damper control signal sequence stop	0-100	100	%
11	DMS_RatioEnable	Ratio damper control signal enable - true=enable	False/true	False	N/a
12	DMS_RampTime	Ramp time damper control signal	1-100	10	%/min

Table 14. Advanced parameters for dampers

7.2.2 Exchanger

No	Name	Description	Range	Default	Units
1	ERT_MinSetpoint	Exchanger temperature low setpoint	0-50	10	°C
2	ERT_MaxSetpoint	Exchanger temperature high setpoint	0-50	15	°C
3	ERT_P_band	Exchanger temperature control P-band	0.01-100	10	100/K

No	Name	Description	Range	Default	Units
4	OAT_MinSetpoint	Minimum outside air temperature	-50-50	-10	°C
5	OAT_MaxSetpoint	Maximum outside air temperature	-50-50	10	°C
6	OAT_FrostProtection	Low limit frost protection	-50-50	6	°C
7	ERS_MinRecovery	Minimum exchanger control signal	0-100	0	%
8	ERS_MaxRecovery	Maximum exchanger control signal	0-100	100	%
9	ERS_StartRatioControl	Ratio exchanger control signal sequence start	0-100	0	%
10	ERS_StopRatioControl	Ratio exchanger control signal sequence stop	0-100	100	%
11	ERS_RatioEnable	Ratio exchanger control signal enable - true=enable	False/true	False	N/a
12	ERP_OffDelay	Exchanger pump switch off delay	0-3600	300	sec
13	ERP_StatusAlarmDelay	Delay status alarm - 0=disable, 1=failure, <0=fail-to-command alarm, >1=status alarm	-600-600	1	sec
14	ERP_Pmp_Vlv_Exercise	Exchanger pump / valve exercise time	0-600	120	sec
15	ERP_WheelRelease	Wheel release - false=plant mode, true=continuous	False/true	False	N/a
16	ERP_OnDelay	Start-up delay pump / wheel	0-300	5	sec

Table 15. Advanced parameters for exchangers

7.2.3 Preheater

No	Name	Description	Range	Default	Units
1	RWT_LowSetpoint	Return water temperature low setpoint	0-100	10	°C
2	RWT_HighSetpoint	Return water temperature high setpoint	0-100	25	°C
3	RWT_MaxSetpoint	Return water temperature maximum setpoint	0-100	85	°C

No	Name	Description	Range	Default	Units
4	RWT_P_band	Return water temperature control P-band	0.01-100	10	100/K
5	DME_OnDelay	Damper enable or alarm delay - 0=alarm disable	0-3600	300	sec
6	DME_EmergencyStop	AHU stops on pump alarm at low outside air temperature - true=yes	False/true	False	N/a
7	OAT_MinSetpoint	Outside air temperature minimum value	-50-50	-10	°C
8	OAT_MaxSetpoint	Outside air temperature maximum value	-50-50	10	°C
9	OAT_FrostProtection	Low limit frost protection	-50-50	6	°C
10	FEZ_RWT_SptUp	Frost protection return water temperature setpoint raise	0-50	15	K
11	FEZ_SetupRamp	Raised setpoint decrease during frost recovery	1-20	1	K/min
12	HPU_OnDelay	Start-up delay heating pump	0-300	5	sec
13	HPU_OffDelay	Heating pump switch off delay	0-3600	300	sec
14	HPU_Enable	Heating pump enable - true=enable	False/true	True	N/a
15	HPU_Pmp_Vlv_Exercise	Heating pump and valve exercise time	0-600	120	sec
16	HPU_StatusAlarmDelay	Delay status alarm - 0=disable, 1=failure, <0=fail-to-command alarm, >1=status alarm	-600-600	1	sec
17	HTS_StartRatioControl	Ratio control signal sequence start	0-100	0	%
18	HTS_StopRatioControl	Ratio control signal sequence stop	0-100	100	%
19	HTS_RatioEnable	Ratio control enable - true=enable	False/true	False	N/a
20	HTV_FrostProt_ValveUp	Heating valve position during frost protection	0-100	100	%
21	HTV_Ramp	Heating valve raised position decrease during frost recovery	1-100	10	%/min

Table 16. Advanced parameters for preheaters

7.2.4 Cooler

No	Name	Description	Range	Default	Units
1	OAT_CoolerLowLimit	Low limit outside air temperature - cooler valve closed	-50-50	14	°C
2	CCV_VlvRamp	Valve position increase per minute	1-100	5	%/min
3	CCV_MinVlvPos	Minimum valve position	0-100	0	%
4	CCV_MaxVlvPos	Maximum valve position	0-100	100	%
5	CCV_Vlv_Exercise	Cooling valve exercise time - 0=disable	0-600	120	sec
6	CCS_StartRatioControl	Ratio temperature control sequence start	0-100	0	%
7	CCS_StopRatioControl	Ratio temperature control sequence stop	0-100	100	%
8	DEH_StartRatioControl	Ratio dehumidification control sequence start	0-100	0	%
9	DEH_StopRatioControl	Ratio dehumidification control sequence stop	0-100	100	%
10	CCS_RatioEnable	Ratio temperature control enable - true=enable	False/true	False	N/a
11	DEH_RatioEnable	Ratio dehumidification control enable - true=enable	False/true	False	N/a
12	CCV_CoolOnHumDisable	Disable cooling on humidify - true=yes	False/true	True	N/a
13	LIM_Setpoint	Low limit setpoint	0-50	14	°C
14	LIM_P_band	Low limit P-band	0.01-100	10	100/K
15	LIM_I_time	Low limit I-time	0-1000	0	100/sec

Table 17. Advanced parameters for coolers

7.2.5 Reheater

No	Name	Description	Range	Default	Units
1	OAT_FrostProtection	Low limit frost protection	-50-50	6	°C
2	HPU_OnDelay	Start-up delay heating pump	0-300	5	sec
3	HPU_OffDelay	Heating pump switch off delay	0-3600	300	sec
4	HPU_Enable	Heating pump enable - true=enable	False/true	True	N/a
5	HPU_Pmp_Vlv_Exercise	Heating pump and valve exercise time	0-600	120	sec
6	HPU_StatusAlarmDelay	Delay status alarm - 0=disable, 1=failure, <0=fail-to-command alarm, >1=status alarm	-600-600	1	sec
7	HTS_StartRatioControl	Ratio control signal sequence start	0-100	0	%
8	HTS_StopRatioControl	Ratio control signal sequence stop	0-100	100	%
9	HTS_RatioEnable	Ratio control enable - true=enable	False/true	False	N/a
10	HTV_FrostProt_ValveUp	Heating valve position during frost protection	0-100	100	%
11	HTV_Ramp	Heating valve raised position decrease during frost recovery	0-100	10	%/min

Table 18. Advanced parameters for reheaters

7.2.6 Fans

No	Name	Description	Range	Default	Units
1	FDP_BeltAlarmDelay	Delay fan belt alarm - 0=disable	0-600	120	sec
2	FSC_OffOnDelay	Delay fan start/stop	0-600	5	sec
3	FSC_Ramp	Control signal increase per minute	0-100	1	%/min
4	FSC_MinSignal	Minimum fan speed control signal	0-100	30	%
5	FSC_MaxSignal	Maximum fan speed control signal	0-100	100	%

No	Name	Description	Range	Default	Units
6	FSC_ManualReset	Manual / automatic alarm reset - false=manual	False/true	False	N/a
7	DSP_PressSptRamp	Setpoint increase per minute	0-1000	50	Pa/min
8	DSP_PressDisP_band	Static discharge pressure control P-band	1-1000	0.5	100/Pa
9	DSP_PressRetP_band	Static return pressure control P-band	1-1000	0.5	100/Pa
10	DSP_PressDisI_time	Static discharge pressure control I-time	0-1000	0	100/sec
11	DSP_PressRetI_time	Static return pressure control I-time	0-1000	0	100/sec
12	DSP_NightReduce	Night reduction of control signal	0-100	50	%

Table 19. Advanced parameters for fans

7.2.7 Humidifier

No	Name	Description	Range	Default	Units
1	OAT_HighHum	High limit for humidification	-50-50	14	°C
2	OAT_LowDeh	Low limit for dehumidification	-50-50	15	°C
3	RAH_MinHumSpt	Minimum room humidity setpoint during winter	0-100	30	%RH
4	RAH_MaxHumSpt	Maximum room humidity setpoint during summer	0-100	60	%RH
5	RAH_P_band	Relative room/return humidity control P-band	0.01-100	25	100/%RH
6	RAH_I_time	Relative room/return humidity control I-time	0-1000	0	100/sec
7	WC_LowOAT	Start point outside air temperature winter compensation	-50-50	-10	°C
8	WC_HighOAT	End point outside air temperature winter compensation	-50-50	10	°C

No	Name	Description	Range	Default	Units
9	SC_LowOAT	Start point outside air temperature summer compensation	-50-50	20	°C
10	SC_HighOAT	End point outside air temperature summer compensation	-50-50	30	°C
11	DAH_MaxSpt	Maximum setpoint discharge air relative humidity	0-100	90	%RH
12	DAH_P_band	Maximum setpoint control P-band	0.01-100	8.33	100/%RH
13	DAH_LowAbsHumSpt	Discharge air absolute humidity low setpoint	0-25	5	g/kg
14	DAH_HighAbsHumSpt	Discharge air absolute humidity high setpoint	0-25	15	g/kg
15	HUM_P_band	Humidification control P-band	0.01-100	35	100/%RH
16	HUM_RampUp	Relative humidity control signal increase per minute	1-100	10	%/min
17	HUM_FanOnDelay	Delay after fan start	0-3600	300	sec
18	HUM_StatusAlarmDelay	Delay status alarm - 0=disable, 1=failure, <0=fail-to-command alarm, >1=status alarm	-600-600	1	sec
19	DEH_P_band	Dehumidification control P-band	0.01-100	16.67	100/%RH
20	DEH_RampUp	Relative humidity control signal increase per minute	1-100	10	%/min
21	HUMDEH_I_time	Humidify / dehumidify control I-time	0-1000	0	100/sec
22	HUMDEH_ComfZone	Comfort zone between humidify / dehumidify	0-40	4	%RH

Table 20. Advanced parameters for humidifiers

7.2.8 Economizer

No	Name	Description	Range	Default	Units
1	AtmPressure	Atmospheric pressure	80-120	101.30	kPa
2	EnthalpyDiff	Enthalpy difference	0-20	5	kJ/kg

No	Name	Description	Range	Default	Units
3	AbsHumDiff	Absolute humidity difference	0.0-5.0	1	g/kg
4	SwitchoverDel	Switch over delay	0-1800	300	sec

Table 21. Advanced parameters for the economizer function

7.2.9 Control

No	Name	Description	Range	Default	Units
1	OAT_HeaterLimit	Limit outside air temperature - heater closed	-50-50	20	°C
2	OAT_CoolerLimit	Limit outside air temperature - cooler closed	-50-50	14	°C
3	OAT_FrostProt	Limit outside air temperature start / frost protection	-50-50	6	°C
4	DAT_LowSetpoint	Discharge air temperature low setpoint	0-50	14	°C
5	DAT_HighSetpoint	Discharge air temperature high setpoint	0-50	26	°C
6	SC_RoomStartComp	Start point outside air temperature summer room temperature compensation	-50-50	20	°C
7	SC_RoomEndComp	End point outside air temperature summer room temperature compensation	-50-50	30	°C
8	SC_RoomSptRaise	Room temperature setpoint raise	0-10	4	K
9	RT_P_band	Room temperature control P-band	0.01-100	50	100/K
10	RT_I_time	Room temperature control I-time	0-1000	0	100/sec
11	RT_ComfortZone	Room temperature comfort zone	0-10	2	K
12	RT_DATSpt_shift	Span for discharge air temperature setpoint shift	0-100	60	%
13	RT_EnergyRecStart	Sequence start point of exchanger	0-100	0	%
14	RT_EnergyRecEnd	Sequence end point of exchanger	0-100	100	%

No	Name	Description	Range	Default	Units
15	WC_DischStartComp	Start point outside air temperature winter discharge air temperature compensation	-50-50	-10	°C
16	WC_DischEndComp	End point outside air temperature winter discharge air temperature compensation	-50-50	10	°C
17	WC_DischSptRaise	Discharge air temperature setpoint raise	0-10	4	K
18	DAT_P_band	Discharge air temperature control P-band	0.01-100	6.67	100/K
19	DAT_I_time	Discharge air temperature control I-time	0-1000	0.17	100/sec
20	DAT_HeatStart	Sequence start point of heating valve	0-100	0	%
21	DAT_HeatEnd	Sequence end point of heating valve	0-100	50	%
22	DAT_EnergyRecStart	Sequence start point of exchanger	0-100	50	%
23	DAT_EnergyRecEnd	Sequence end point of exchanger	0-100	75	%
24	DAT_CoolStart	Sequence start point of cooling valve	0-100	75	%
25	DAT_CoolEnd	Sequence end point of cooling valve	0-100	100	%
26	DAT_SptRamp	Discharge air temperature setpoint raise	0-20	1	K
27	DAT_SptDecTime	Discharge air temperature control raised setpoint decrease time	0-3600	600	sec
28	HUM_FanStart	Sequence start point of fan speed	0-100	0	%
29	HUM_FanEnd	Sequence end point of fan speed	0-100	100	%
30	DEH_DampersStart	Sequence start point dampers	0-100	0	%
31	DEH_DampersEnd	Sequence end point dampers	0-100	30	%
32	DEH_FanStart	Sequence start point of fan speed	0-100	30	%
33	DEH_FanEnd	Sequence end point of fan speed	0-100	70	%
34	DEH_CoolStart	Sequence start point of cooling valve	0-100	70	%

No	Name	Description	Range	Default	Units
35	DEH_CoolEnd	Sequence end point of cooling valve	0-100	100	%
36	CO2_P_band	Air quality control P-band	0.01-100	0.5	100/ppm
37	CO2_DampersStart	Sequence start point air quality override dampers	0-100	0	%
38	CO2_DampersEnd	Sequence end point air quality override dampers	0-100	50	%
39	CO2_FanStart	Sequence start point air quality override fan speed	0-100	50	%
40	CO2_FanEnd	Sequence end point air quality override fan speed	0-100	100	%
41	MAD_RecircTimeStart	Period of forced recirculation after start	0-3600	600	sec

Table 22. Advanced control parameters

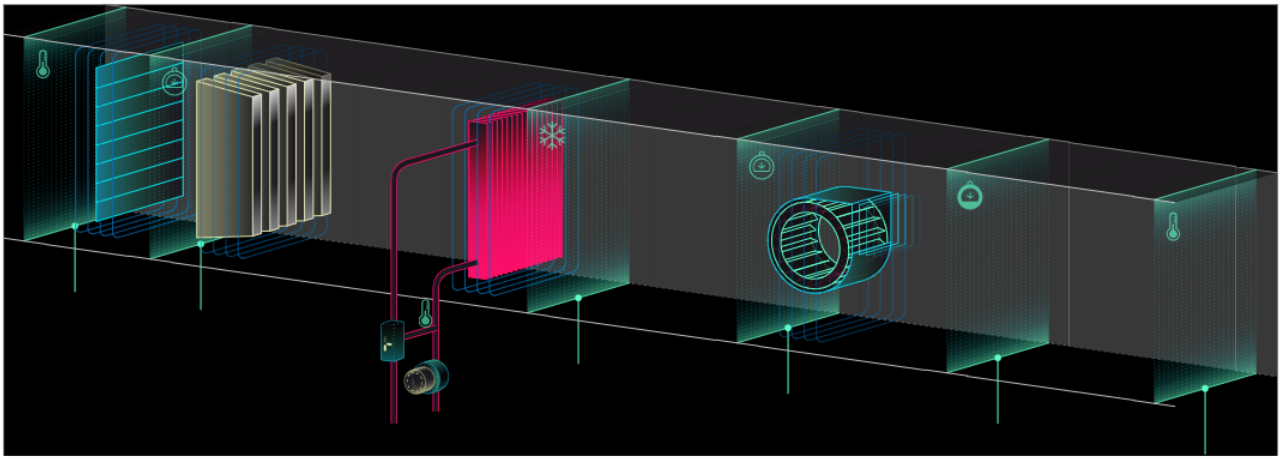
8 AHU Application Examples

The AHU application can be configured for 8 different modes depending on the physical configuration of the air handling unit:

- example 1: supply air handling unit with water heater (and, optionally, water cooler);
- example 2: supply air handling unit with water heaters, water cooler, and humidification and dehumidification function;
- example 3: supply and exhaust air handling unit with water heater (and, optionally, water cooler);
- example 4: supply and exhaust air handling unit with water heaters and water cooler, with humidification and dehumidification function;
- example 5: supply and exhaust air handling unit with wheel exchanger, water heaters and water cooler, with humidification and dehumidification function;
- example 6: supply and exhaust air handling unit with cross-flow exchanger, water heaters and water cooler, with humidification and dehumidification function;
- example 7: supply and exhaust air handling unit with mixing dampers, water heaters and water cooler, with humidification and dehumidification function;
- example 8: supply and exhaust air handling unit with twin-coil exchanger, water heaters and water cooler, with humidification and dehumidification function.

8.1 Example 1

8.1.1 Supply Air Handling Unit with Water Heater (and, Optionally, Water Cooler)



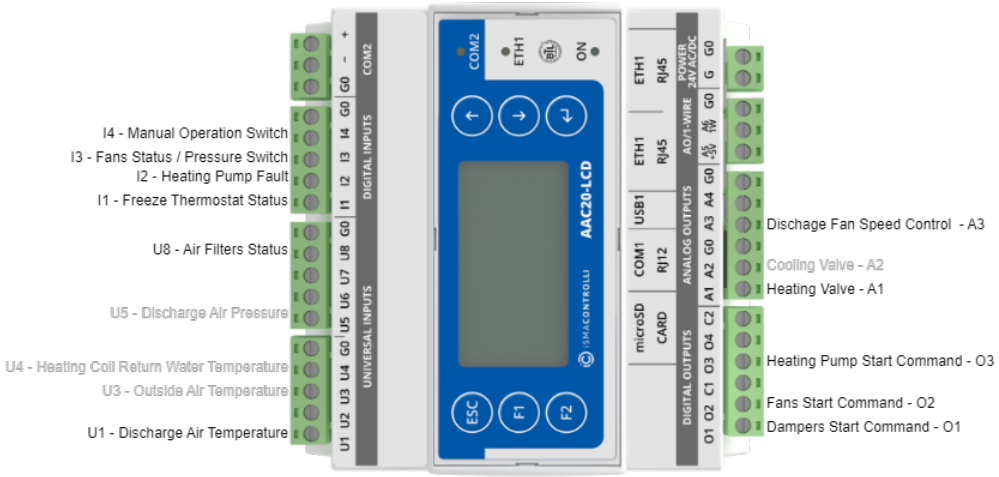


Figure 81. Inputs and outputs configured for supply air handling unit with water heater

The air handling unit consists of:

- 2-position inlet damper;
- air supply filter;
- water heater with a valve and a heater pump;
- fan controlled by an inverter.

The required sensors/signals are:

- discharge air temperature sensor;
- anti-freeze thermostat;
- fan operating status (pressure switch, signal from the inverter);
- manual switch control (permission to operate the ventilation system).

Some of the useful sensors/signals, optional but not required:

- heater pump failure status;
- filter dirty status (for monitoring only).

In addition, the system can be equipped with optional sensors/signals, such as:

- outside air temperature;

- heater return water temperature;
- discharge air pressure sensor (only when there is a need to maintain constant pressure on the supply duct).

The application allows for:

- controlling the opening/closing of the 2-position inlet damper;
- the fan to start, controlling its speed (constant or pressure dependent);
- controlling the modulating (analog 0-10 V DC) heater valve actuator and the heater pump.

In addition, if a water cooler is also configured, it will be controlled by the modulating (analog 0-10 V DC) cooler valve actuator (here, an outside air temperature sensor is required – i.e., to disable using the cooler in winter).

AHU configuration example:

- heater mode – **Heater [1]**
- energy recovery mode – **None [0]**
- cooler mode – **None or Cooler [0 or 1]** (depending on the need)
- humidifier mode – **None [0]**
- economizer mode – **None [0]**
- temperature control mode – **Constant Disch Temp [2]**
- humidity control mode – n/a

8.1.2 Application Algorithm Description

Start-up

1. The first step after configuring the application for a particular type of the AHU is to make sure that the time schedule is correctly configured, which allows the AHU to run in a normal mode (Plant Mode as Occupied Period [4]) or in a night mode (with reduced efficiency - Plant Mode as Night Cycle [2]). If not, the time schedule must first be set correctly to allow a proper AHU operation.
2. The signal that allows the AHU to start is the signal connected to the I4 input of the AAC20 (Operating Switch). Activating this signal (physical short circuit at the input) and correctly setting the time schedule allows the AHU to start, while deactivating the signal automatically stops the AHU.

Preheater

1. The next step before starting the AHU is for the controller to verify that the heater has no active alarm conditions associated with the antifreeze protection procedure.
2. The antifreeze protection of the heater is used in the winter period (when the outside temperature is lower than the limit set by OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K).
3. The basic element is an antifreeze thermostat whose physical setting should be in accordance with or slightly lower than the above limit (e.g., by 1°C). The antifreeze thermostat is connected to the I1 input in the AAC20 controller (Freeze Thermostat Status).
4. Activation of the antifreeze thermostat (physical short circuit at the input) triggers the antifreeze protection procedure consisting of stopping the AHU (turning off the fan and closing the damper), opening the heater valve at output A1 of the AAC20 (Heating

Valve) to the level specified in HTV_FrostProt_ValveUp (by default, 100%), and switching on the heater pump at the O3 output (Heating Pump Start Command) if configured for use by HPU_Enable (by default, active - true).

5. An additional element of antifreeze protection is the use of a return water temperature sensor connected to the U4 input in the AAC20 (Heating Coil Return Water Temperature). If the antifreeze thermostat is triggered, the setpoint for the return water temperature is raised additionally by the level specified in FEZ_RWT_SptUp (by default, 15K).
6. When the temperature of the heater rises and the antifreeze thermostat returns to the normal state: in such case, if there is a sensor for the water temperature at the return from the heater, its setpoint will begin to fall at the rate of FEZ_SetupRamp (default 1K/min) to the normal setpoint (calculated on the basis of the outside temperature); if there is no sensor, the valve closes at the rate of HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current system control.
7. The heater return water temperature sensor also serves as a high limit for the water temperature in the heater by closing the valve if the temperature specified in RWT_MaxSetpoint is too high (85°C by default).
8. If the pump is activated in HPU_Enable (active by default - true) and connected to the O3 output in the AAC20 (Heating Pump Start Command), it is switched on with the delay HPU_OnDelay (by default, 5 s) when the heater valve connected to the A1 output in the AAC20 (Heating Valve) opens to 3% or more, and switched off with the delay specified in HPU_OffDelay (by default, 300 s) when the valve is open 1% or less.
9. In winter, the pump is permanently activated if the outside temperature falls below the OAT_FrostProtection limit (by default, 6°C) with a central hysteresis of 1K and if the antifreeze thermostat is activated.
10. When using the pump failure signal, which is connected to the I2 input on the AAC20 (Heating Pump Fault), and when the value in HPU_StatusAlarmDelay (by default, 1 s) is set to default, then in the winter period the AHU can be turned off if:
    a. DME_EmergencyStop (deactivated by default - false) is active (set to true),
    b. an alarm is generated on the O2 output of the MIX18 module (Heat Pumps Failure Alarm),
    c. and the pump control output is turned off.
    The alarm is automatically reset if the signal at the input is deactivated and the pump and AHU system resume operation (if stopped).
11. An additional feature to ensure a proper and long-lasting operation of the devices operating the heater is exercising the pump and valve. First, the pump is exercised, then the valve, which, by default, takes place every Sunday at 1am in case they are not in use. The exercise consists of turning on the pump for the time specified in HPU_Pmp_Vlv_Exercise (120 s by default) and then opening the valve to 100% for the same time as above.

Dampers

1. In winter, when the outside temperature is lower than the limit specified by OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K and if the return water temperature sensor is used, then, it must reach the setpoint (calculated from the outside temperature) to allow the dampers to open after the time specified in DME_OnDelay (by default, 300 s).

2. If the return water temperature sensor from the heater is not used, the damper is opened only after the time specified in DME_OnDelay (by default, 300 s), during which the valve is opened according to the HTV_FrostProt_ValveUp parameter (by default, 100%) and drops at the rate specified by HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current system control.
3. When the outside temperature is above the limit specified in OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K (summer period), the damper is opened without the delay specified in DME_OnDelay (by default, 300 s) and the heater return water temperature is not controlled at that time.
4. The damper connected to the O1 output in the AAC20 (Dampers Start Command) opens after the time specified in DME_OnDelay (by default, 300 s) only after the permission from the normally operating heater, and then the signal from the damper is transmitted as a start permission for the fan with a delay of MAD_RunTime (by default, 150 s).

Fans

1. If a pressure sensor is connected at the U5 input in the AAC20 (Discharge Air Pressure), the fan is controlled smoothly connected at the A3 output in the AAC20 (Discharge Fan Speed Control) in the range from FSC_MinSignal (by default, 30%) to FCS_MaxSignal (by default, 100%) so as to maintain the set pressures. Otherwise, if no pressure sensor is connected, the fan is controlled manually with the set speed in above (higher control value is selected).
2. The fan has its preset DischPressSpt pressure (500 Pa by default), which it is supposed to maintain by adjusting its speed accordingly.
3. The fan connected to the O2 output in the AAC20 (Fans Start Command) starts with the delay specified in FSC_OffOnDelay (by default, 5 s) after receiving a permission from the damper.
4. After receiving the startup permission, the fan speed control signal slowly ramps up at the rate of FSC_Ramp (by default, 1%/min) to the desired value resulting from the corresponding control as indicated above. The rate of rise or fall of the control signal is determined by the same speed.
5. The pressure setpoint behaves similarly, which during the AHU startup ramps up from zero to the desired setpoint at the speed of DSP_PressSptRamp (by default, 50 Pa/min). If it is changed during a normal operation, it will correspondingly start falling or rising at the same speed specified in DSP_PresSptRamp (by default, 50 Pa/min).
6. For a night mode, the set pressure is reduced by multiplying it by the DSP_NightReduce factor (by default, 50%).
7. To protect the fan operation, a fan confirmation signal is connected to the I3 input in the AAC20 (Fans Status/Pressure Switch), which if not activated by the time FDP_BeltAlarmDelay (default 120s), then, an alarm is generated on the O1 output of MIX18 (Fans Failure Alarm) and this causes the AHU to stop. This function can be disabled by setting the zero value in FDP_BeltAlarmDelay (by default, 120 s).
8. In the automatic reset mode specified in FSC_ManualReset (by default, false), after an alarm from the fan, the alarm will be reset and the AHU will resume operation, while after three unsuccessful attempts to start, the system stops and in the automatic mode it can be reset by removing and reactivating the I4 input in AAC20 (Operating Switch). While if the manual reset mode specified in FSC_ManualReset (deactivated - false by default) is set to true, after an alarm from the fan, the AHU will be stopped and

the controller will wait for a reset signal activated by the input connected to the I5 input in MIX18 (Reset), and only then will it attempt to restart the AHU.

Control

1. In winter, during the AHU startup, the temperature control system temporarily raises the setpoint for the discharge temperature by an additional value specified in DAT_SptRamp (by default, 1K) which drops in time specified in DAT_SptDecTime (by default, 600 s).
2. For proper operation of the TempCtrlMode temperature control function, select mode 2 as described below.
3. The fixed-value temperature control function consists of adjusting the discharge air temperature connected at the U1 input of the AAC20 controller (Discharge Air Temperature) based on the set TempSpt temperature (by default, 22°C), and based on the control loop the control level for the heater or cooler is calculated.
4. If the discharge air temperature falls below the low limit, the cooler is gradually closed, and then the heater starts to open.
5. If the discharge air temperature rises above the high limit, the heater is gradually closed, and then the cooler starts to open.
6. The TempSpt temperature setpoint (by default, 22°C) can take into account the winter compensation specified by the WC_DischSptRaise parameter (by default, 4K) or the summer compensation specified by the SC_DischSptRaise parameter (by default, 4K).
7. In summer, if the outside temperature rises above the OAT_HeaterLimit (by default, 20°C), heater control is blocked, and in winter, if the outside temperature falls below the OAT_CoolerLimit (by default, 14°C), cooler control is blocked.
8. When the antifreeze protection is triggered, all control signals are reset except for the signal for the heater which is set to the level specified in HTV_FrostProt_ValveUp (by default, 100%). When the risk of freezing ceases, all signals return to normal operation.
9. The heater valve is opened or closed by the valve actuator according to the control signal coming from the temperature control system according to the configured TempCtrlMode (in mode 2).

Cooler

1. When cooling is needed, the cooler valve connected to the A2 output (Cooling Valve) opens based on a signal coming from the temperature control system.
2. The control of the cooler valve is blocked below the OAT_CoolerLowLimit temperature (by default, 14°C) with a central hysteresis of 1K.
3. During the AHU startup and each time the valve is opened from zero, the control signal gradually increases at the rate specified in CCV_VlvRamp (by default, 5%/min).
4. To protect against too low air temperature behind the cooler, it is possible to use a temperature sensor connected to the U3 input on the MIX18 module (Cooling Limit Air Temperature) causing the cooler valve to gradually close when the temperature drops to the LIM_Setpoint value (by default, 14°C).
5. An additional feature to ensure a proper and long-lasting operation of the cooler is exercising the valve. It is carried out by default every Sunday at 1am in case it is not being used. Exercise consists of opening the valve to 100% for the time specified in CCV_Vlv_Exercise (120 s by default).

8.1.3 Electrical Connections

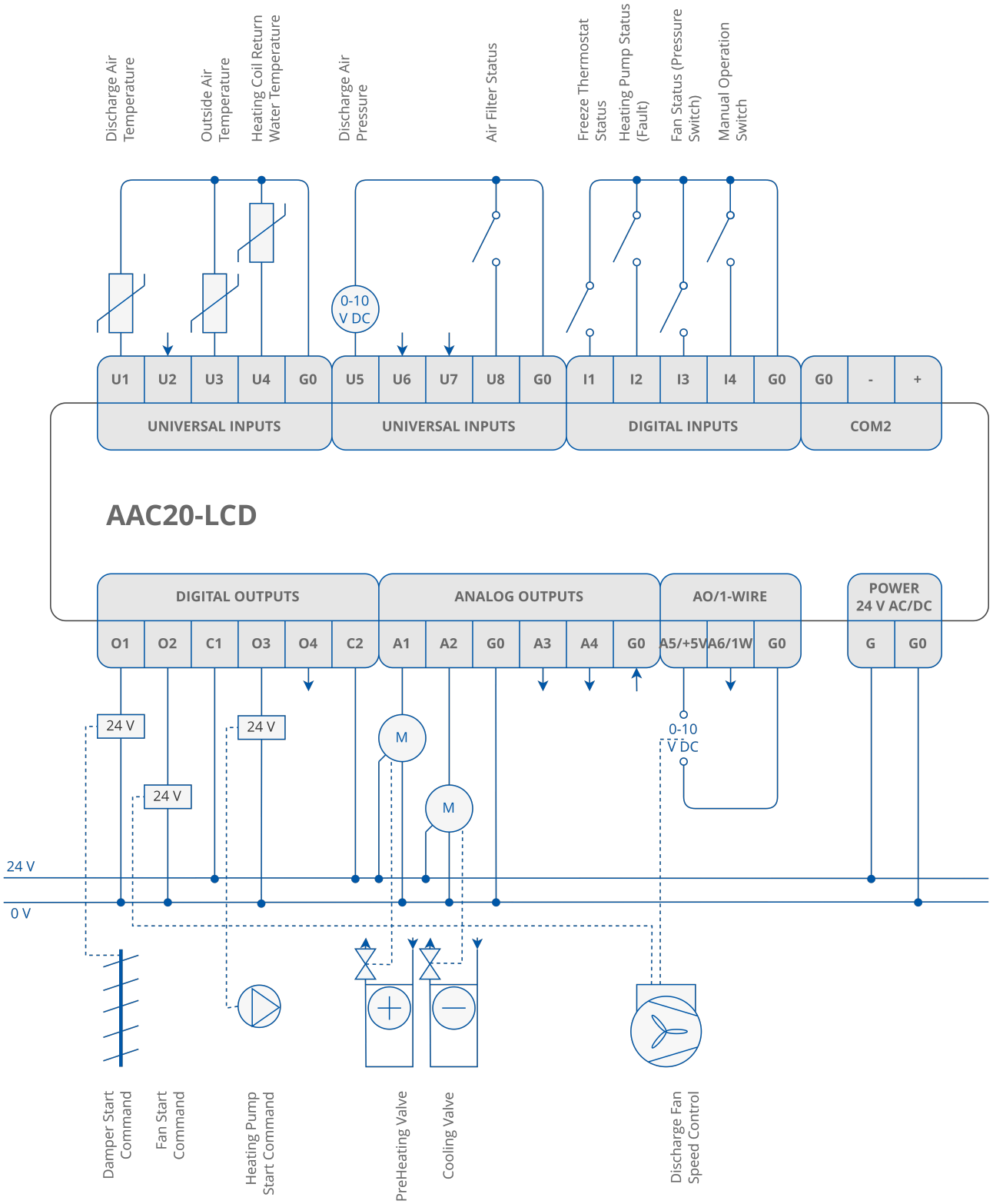


Figure 82. Electrical connections for supply air handling unit with water heater

8.2 Example 2

8.2.1 Supply Air Handling Unit with Water Heaters, Water Cooler, and Humidification and Dehumidification Function

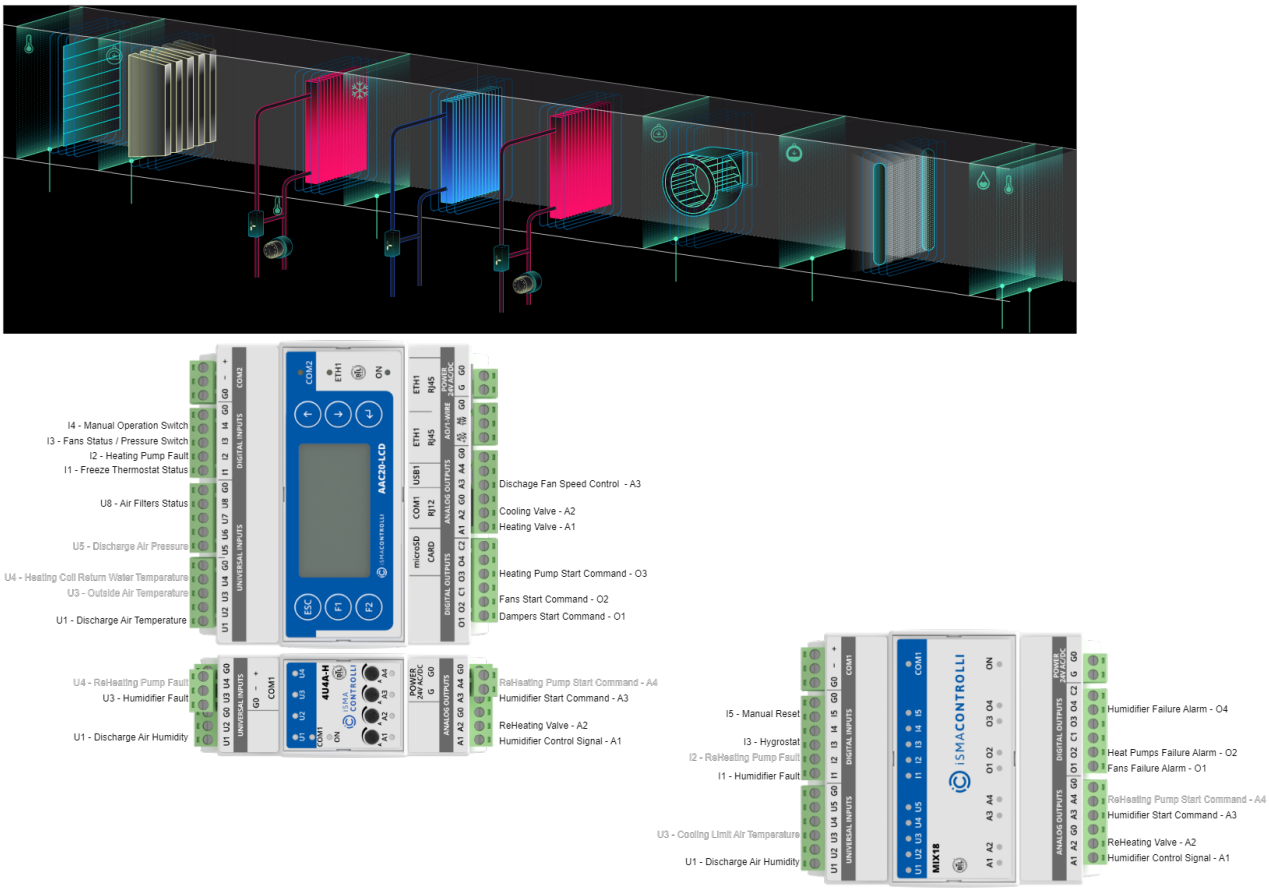


Figure 83. Inputs and outputs configured for supply air handling unit with water heaters, water cooler, and humidification and dehumidification function

The air handling unit consists of:

- 2-position inlet damper;
- air supply filter;
- water preheater with a valve and a preheater pump;
- water cooler with a valve;
- water reheater with a valve and a optionally reheater pump;
- fan controlled by an inverter;
- humidifier.

To enable humidity control in the humidification and dehumidification function, it is required to add an extension I/O module, iSMA-B-4U4A or -MIX18, to the AAC20 controller (depending on the demand and required sensors/signals). The required sensors/signals are:

- discharge air temperature sensor;
- discharge air humidity sensor;
- anti-freeze thermostat;
- humidifier failure status (can be used in conjunction with a hygrostat for the MINI module);

- hygrostat (if is required and installed);
- fan operating status (pressure switch, signal from the inverter);
- manual switch control (permission to operate the ventilation system).

Some of the useful sensors/signals, optional but not required:

- preheat pump failure status;
- reheat pump failure status (if reheat pump is installed);
- filter dirty status (for monitoring only);
- manual reset (for MIX18 only, in case of manual fault reset).

In addition, the system can be equipped with extra sensors/signals, such as:

- outside air temperature;
- heater return water temperature;
- cooler limit air temperature;
- discharge air pressure sensor (only when there is a need to maintain constant pressure on the supply duct).

The application allows for:

- controlling the opening/closing of the 2-position inlet damper:
- the fan to start and controlling its speed (constant, or pressure dependent);
- controlling the modulating (analog 0-10 V DC) preheater valve actuator and the preheater pump;
- controlling the modulating (analog 0-10 V DC) reheater valve actuator (used for the dehumidification function) and the optional reheater pump;
- controlling the modulating (analog 0-10 V DC) cooler valve actuator;
- allowing the humidifier to start and controlling its humidification performance.

If the MIX18 module is used, it is also possible to signal alarm states for the fan, heaters pump (common alarm), and humidifier.

AHU configuration example:

- heater mode – **PreHeater & ReHeater [2]**
- energy recovery mode – **None [0]**
- cooler mode – **Cooler [1]**
- humidifier mode – **Water Humidifier or Steam Humidifier [1 or 2]** (depending on the need)
- economizer mode – **None [0]**
- temperature control mode – **Constant Disch Temp [2]**
- humidity control mode – **Constant Disch Abs Hum [4]**

8.2.2 Application Algorithm Description

Start-up

1. The first step after configuring the application for a particular type of the AHU is to make sure that the time schedule is correctly configured, which allows the AHU to run in a normal mode (Plant Mode as Occupied Period [4]) or in a night mode (with reduced efficiency - Plant Mode as Night Cycle [2]). If not, the time schedule must first be set correctly to allow a proper AHU operation.
2. The signal that allows the AHU to start is the signal connected to the I4 input of the AAC20 (Operating Switch). Activating this signal (physical short circuit at the input) and

correctly setting the time schedule allows the AHU to start, while deactivating the signal automatically stops the AHU.

Preheater

1. The next step before starting the AHU is for the controller to verify that the heater has no active alarm conditions associated with the antifreeze protection procedure.
2. The antifreeze protection of the heater is used in the winter period (when the outside temperature is lower than the limit set by OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K).
3. The basic element is the antifreeze thermostat whose physical setting should be in accordance with or slightly lower than the above limit (e.g., by 1°C). The antifreeze thermostat is connected to the I1 input on the AAC20 controller (Freeze Thermostat Status).
4. Activation of the antifreeze thermostat (physical short circuit at the input) triggers the antifreeze protection procedure consisting of stopping the AHU (turning off the fan and closing the damper), opening the heater valve at the A1 output of the AAC20 (Heating Valve) to the level specified in HTV_FrostProt_ValveUp (by default, 100%), and switching on the heater pump at the O3 output (Heating Pump Start Command) if configured for use by HPU_Enable (by default, active - true).
5. An additional element of antifreeze protection is the use of a return water temperature sensor connected to the U4 input in the AAC20 (Heating Coil Return Water Temperature). If the antifreeze thermostat is triggered, the setpoint for the return water temperature is raised additionally by the level specified in FEZ_RWT_SptUp (by default, 15K).
6. When the temperature of the heater rises and the antifreeze thermostat returns to the normal state: in such case, if there is a sensor for the water temperature at the return from the heater, its setpoint will begin to fall at the rate of FEZ_SetupRamp (default 1K/min) to the normal setpoint (calculated on the basis of the outside temperature); if there is no sensor, the valve closes at the rate of HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current system control.
7. The heater return water temperature sensor also serves as a high limit for the water temperature in the heater by closing the valve if the temperature specified in RWT_MaxSetpoint is too high (85°C by default).
8. If the pump is activated in HPU_Enable (active by default - true) and connected to the O3 output in the AAC20 (Heating Pump Start Command), it is switched on with the delay HPU_OnDelay (by default, 5 s) when the heater valve connected to the A1 output in the AAC20 (Heating Valve) opens to 3% or more, and switched off with the delay specified in HPU_OffDelay (by default, 300 s) when the valve is opened 1% or less.
9. In winter, the pump is permanently activated if the outside temperature falls below the OAT_FrostProtection limit (by default, 6°C) with a central hysteresis of 1K and if the antifreeze thermostat is activated.
10. When using the pump failure signal, which is connected to the I2 input on the AAC20 (Heating Pump Fault), and when the value in HPU_StatusAlarmDelay (by default, 1 s) is set to default, then in the winter period the AHU can be turned off if:
    a. DME_EmergencyStop (deactivated by default - false) is active (set to true),
    b. an alarm is generated on the O2 output of the MIX18 module (Heat Pumps Failure Alarm), and

c. the pump control output is turned off.
The alarm is automatically reset if the signal at the input is deactivated and the pump and AHU system resume operation (if stopped).

11. An additional feature to ensure a proper and long-lasting operation of the devices operating the heater is exercising the pump and valve. First, the pump is exercised, then the valve, which, by default, takes place every Sunday at 1am in case they are not in use. The exercise consists of turning on the pump for the time specified in HPU_Pmp_Vlv_Exercise (120 s by default) and then opening the valve to 100% for the same time as above.

Dampers

1. In winter, when the outside temperature is lower than the limit specified by OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K and if the return water temperature sensor is used, then, it must reach the setpoint (calculated from the outside temperature) to allow the dampers to open after the time specified in DME_OnDelay (by default, 300 s).
2. If the return water temperature sensor from the heater is not used, the damper is opened only after the time specified in DME_OnDelay (by default, 300 s), during which the valve is opened according to the HTV_FrostProt_ValveUp parameter (by default, 100%) and drops at the rate specified by HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current system control.
3. When the outside temperature is above the limit specified in OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K (summer period), the damper is opened without the delay specified in DME_OnDelay (by default, 300 s) and the heater return water temperature is not controlled at that time.
4. The damper connected to the O1 output in the AAC20 (Dampers Start Command) opens after the time specified in DME_OnDelay (by default, 300 s) only after the permission from the normally operating heater, and then the signal from the damper is transmitted as a start permission for the fan with a delay of MAD_RunTime (by default, 150 s).

Fans

1. If a pressure sensor is connected at the U5 input in the AAC20 (Discharge Air Pressure), the fan in is controlled smoothly connected at the A3 output in the AAC20 (Discharge Fan Speed Control) in the range from FSC_MinSignal (by default, 30%) to FCS_MaxSignal (by default, 100%) so as to maintain the set pressures, or is controlled from the control signal resulting from humidity or manually with a set speed in the above ranges in the absence of connected pressure sensors (the higher control value is selected).
2. The fan has its preset DischPressSpt pressure (500 Pa by default), which it is supposed to maintain by adjusting its speed accordingly.
3. The fan connected to the O2 output in the AAC20 (Fans Start Command) starts with the delay specified in FSC_OffOnDelay (by default, 5 s) after receiving a permission from the damper.
4. After receiving the startup permission, the fan speed control signal slowly ramps up at the rate of FSC_Ramp (by default, 1%/min) to the desired value resulting from the corresponding control as indicated above. The rate of rise or fall of the control signal is determined by the same speed.

5. The pressure setpoint behaves similarly, which during the AHU startup ramps up from zero to the desired setpoint at the speed of DSP_PressSptRamp (by default, 50 Pa/min). If it is changed during a normal operation, it will correspondingly start falling or rising at the same speed specified in DSP_PresSptRamp (by default, 50 Pa/min).
6. For a night mode, the set pressure is reduced by multiplying it by the DSP_NightReduce factor (by default, 50%).
7. To protect the fan operation, a fan confirmation signal is connected to the I3 input in the AAC20 (Fans Status/Pressure Switch), which if not activated by the time FDP_BeltAlarmDelay (default 120s), then, an alarm is generated on the O1 output of MIX18 (Fans Failure Alarm) and this causes the AHU to stop. This function can be disabled by setting the zero value in FDP_BeltAlarmDelay (by default, 120 s).
8. In the automatic reset mode specified in FSC_ManualReset (by default, false), after an alarm from the fan, the alarm will be reset and the AHU will resume operation, while after three unsuccessful attempts to start, the system stops and in the automatic mode it can be reset by removing and reactivating the I4 input in AAC20 (Operating Switch). While if the manual reset mode specified in FSC_ManualReset (deactivated - false by default) is set to true, after an alarm from the fan, the AHU will be stopped and the controller will wait for a reset signal activated by the input connected to the I5 input in MIX18 (Reset) and only then will it attempt to restart the AHU.

Control

1. In winter, during the AHU startup, the temperature control system temporarily raises the setpoint for the discharge temperature by an additional value specified in DAT_SptRamp (by default, 1K) which drops in time specified in DAT_SptDecTime (by default, 600 s).
2. For proper operation of the TempCtrlMode temperature control function, select mode 2 as described below.
3. The fixed-value temperature control function consists of adjusting the discharge air temperature connected at the U1 input of the AAC20 controller (Discharge Air Temperature) based on the set TempSpt temperature (by default, 22°C), and based on the control loop the control level for the heater or cooler is calculated.
4. If the discharge air temperature falls below the low limit, the cooler is gradually closed, and then the heater starts to open.
5. If the discharge air temperature rises above the high limit, the heater is gradually closed, and then the cooler starts to open.
6. The TempSpt temperature setpoint (by default, 22°C) can take into account the winter compensation specified by WC_DischSptRaise (by default, 4K) or the summer compensation specified by SC_DischSptRaise (by default, 4K).
7. In the case of active humidification function, the fan speed can gradually increase with the humidifier control signal, as long as pressure control is not used and the manual setting is lower than the humidification control function.
8. In summer, if the outside temperature rises above the OAT_HeaterLimit (by default, 20°C), heater control is blocked, and in winter, if the outside temperature falls below the OAT_CoolerLimit (by default, 14°C), cooler control is blocked.
9. When the antifreeze protection is triggered, all control signals are reset except for the signal for the heater which is set to the level specified in HTV_FrostProt_ValveUp (by default, 100%). When the risk of freezing ceases, all signals return to normal operation.

10. The heater valve is opened or closed by the valve actuator according to the control signal coming from the temperature control system according to the configured TempCtrlMode (in mode 2).

Reheater

1. When HeaterMode (mode 2) is selected as operation mode for both primary and secondary heaters, then when the humidification function is active, only the primary heater works, and when the dehumidification function is active, only the secondary heater is used for temperature control.
2. If no humidity control is used (or no active humidification or dehumidification function), both heaters work simultaneously in the temperature control function, but can be configured as needed for gradual operation (the primary heater is the first stage, and the secondary is the second).
3. If the secondary heater pump is activated in HPU_Enable (active by default - true) and connected to the A4 output of the module 4U4A-H or MIX18 (ReHeating Pump Start Command), it is switched on with the delay HPU_OnDelay (by default, 5 s) when the secondary heater valve connected to the A2 output in the module 4U4A-H or MIX18 (ReHeating Valve) opens to 3% or more, and is switched off with the delay specified in HPU_OffDelay (by default, 300 s) when the valve is opened to 1% or less.
4. In winter, when the outdoor temperature drops below the OAT_FrostProtection value (by default, 6°C) at the start of the AHU system, the secondary heater valve opens according to the HTV_FrostProt_ValveUp parameter (by default, 100%) and drops at the rate specified by HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current control system control.
5. In winter, the secondary heater pump is permanently activated if the outdoor temperature falls below the OAT_FrostProtection limit (by default, 6°C) with a central hysteresis of 1K.
6. When using the secondary heater pump failure signal which is connected to the U4 input of the module 4U4A-H or the I2 input of the module MIX18 (ReHeating Pump Fault) and when the value in HPU_StatusAlarmDelay (by default, 1 s) is set to default, an alarm is generated on the O2 output of the module MIX18 (Heat Pumps Failure Alarm) and the pump control output is disabled. The alarm is automatically reset if the input signal is deactivated and the pump resumes operation.
7. An additional feature to ensure a proper and long-lasting operation of the devices operating the secondary heater is exercising of the pump and valve. First, the pump is exercised, then the valve, which, by default, takes place every Sunday at 1am in case they are not in use. The exercise consists of turning on the pump for the time specified in HPU_Pmp_Vlv_Exercise (120 s by default) and then opening the valve to 100% for the same time as above.

Cooler

1. When cooling is needed, the cooler valve connected to the A2 output (Cooling Valve) opens based on a stronger signal coming from the temperature control system or dehumidification function.
2. The control of the cooler valve is blocked below the OAT_CoolerLowLimit temperature (by default, 14°C) with a central hysteresis of 1K.
3. It is possible to block the control of the cooler valve in the humidification function with the CCV_CoolOnHumDisable parameter (active by default – true).

4. During the AHU startup and each time the valve is opened from zero, the control signal gradually increases at the rate specified in CCV_VlvRamp (by default, 5%/min).
5. To protect against too low air temperature behind the cooler, it is possible to use a temperature sensor connected to the U3 input on the MIX18 module (Cooling Limit Air Temperature) causing the cooler valve to gradually close when the temperature drops to the LIM_Setpoint value (by default, 14°C).
6. An additional feature to ensure a proper and long-lasting operation of the cooler is exercising the valve. It is carried out by default every Sunday at 1am in case it is not being used. Exercise consists of opening the valve to 100% for the time specified in CCV_Vlv_Exercise (120 s by default).

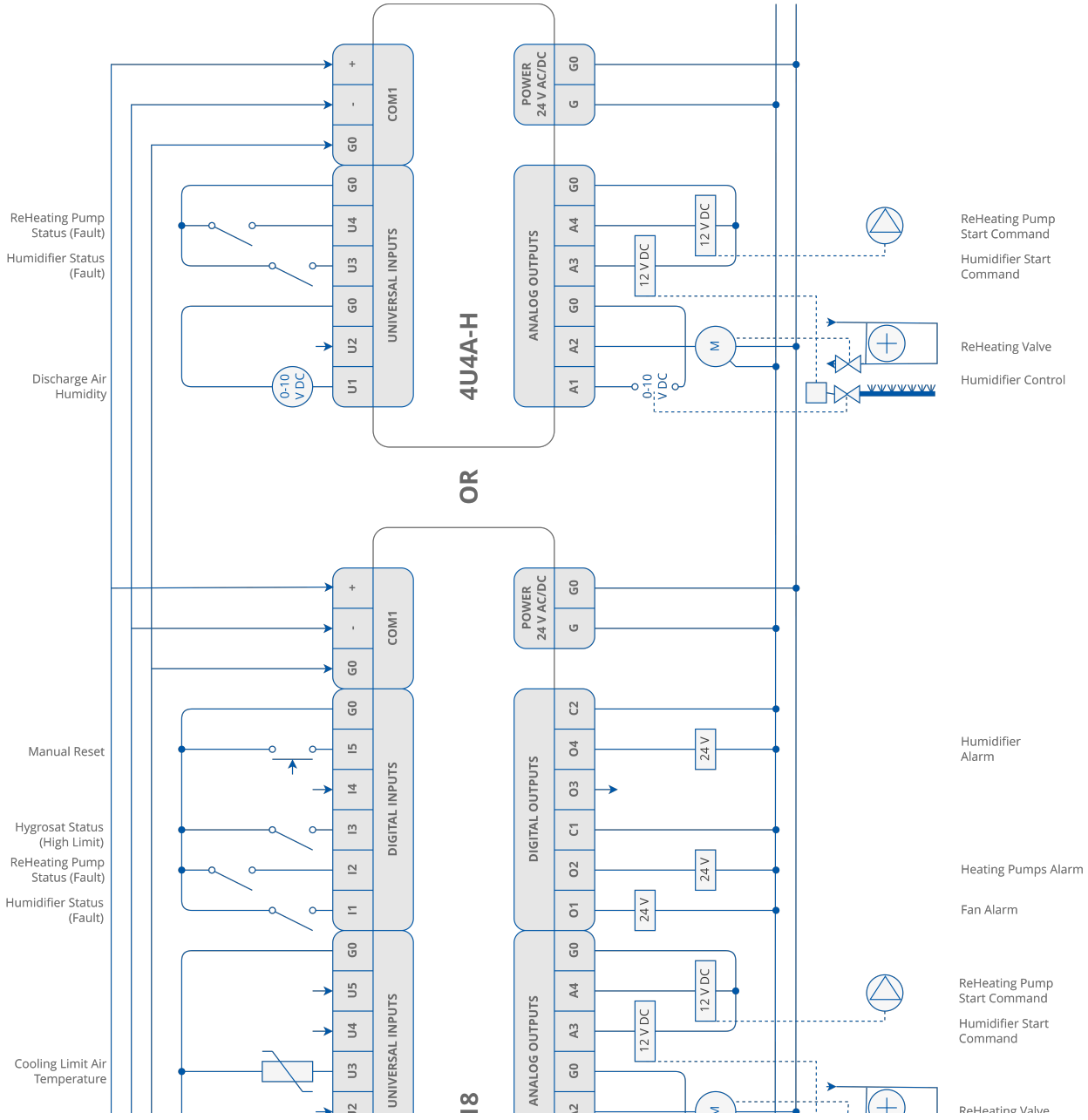
Humidifier

1. The AHU is also equipped with a humidification and dehumidification function. The humidification function is started with a delay of HUM_FanOnDelay (by default, 300 s) after confirming the operation of the fan connected to the I3 input in the AAC20 (Fans Status/Pressure Switch).
2. In case of lack of confirmation that the fan connected to the I3 input of the AAC20 (Fans Status/Pressure Switch) is operating, the humidification function is turned off immediately.
3. The humidification function is active when the outdoor temperature is lower than the OAT_HighHum parameter (by default, 14°C), and the dehumidification function is active when the outdoor temperature is higher than the OAT_LowDeh parameter (by default, 15°C).
4. A sensor on the discharge air connected to the U1 input of the module 4U4A-H or MIX18 (Discharge Air Humidity) is required to implement the humidity control.
5. For a proper operation of the HumCtrlMode humidity control function, select mode 4 as described below.
6. The function of a fixed-value absolute humidity control of the discharge air consists of adjusting the humidity so as to achieve the HumSpt as the setpoint for the supply air (by default, 55%) using the humidification or dehumidification function. To implement this function, an absolute humidity sensor (not relative humidity) connected on the discharge air is required.
7. The humidity control function has two independent control loops, one for humidification control directly controlling the humidifier connected to the A1 output of the AAC20 controller (Humidifier Control Signal), and the other for dehumidification control affecting the control of the cooler connected to the A2 output of the AAC20 controller (Cooling Valve). The maintenance of the previously reduced temperature to the set level according to the temperature control is done by controlling the secondary heater connected to the A2 output of the 4U4A-H or MIX18 module (ReHeating Valve).
8. Both humidification and dehumidification control functions ramp up gradually at the speed of HUM_RampUp (by default, 10%/min) and DEH_RampUp (by default, 10%/min), respectively.
9. The HumSpt set humidity (by default, 55%) can take into account either winter compensation determined by a linear function in relation to the outside temperature from RAH_MinHumSpt (by default, 30%Rh) to HumSpt (by default, 55%) or summer compensation determined by a linear function in relation to the outside temperature from HumSpt (by default, 55%) to RAH_MaxHumSpt (by default, 60%Rh).
10. Depending on the type of humidifier selected in HumidifierMode, the A3 output control in the 4U4A-H or MIX18 module (Humidifier Start Command) is activated as

required: as a water humidifier pump (mode 1) or as switched on permanently (if there is no failure) during AHU operation as a steam humidifier enabler (mode 2).

11. In case of a humidifier failure activated at the U3 input of the 4U4A-H module or at the I1 input of the MIX18 module (Humidifier Fault), the humidifier control is turned off, the water humidifier pump/steam humidifier is shut down, and an alarm is generated at the O4 output of the MIX18 module (Humidifier Failure Alarm).
12. In addition to the hygrostat connected to the I3 input of the MIX 18 module (Hygrostat), which, when activated, turns off the humidification function (turns off the humidifier and pump / permit control), there is also a function to protect the occurrence of too much discharge humidity (to prevent the ducts from getting wet). If the supply air humidity begins to increase towards the DAH_MaxSpt value (by default, 90%), then the humidifier control gradually decreases to zero.
13. Deactivation of the humidistat or humidifier failure automatically resets the alarm and returns to normal control mode.

8.2.3 Electrical Connections



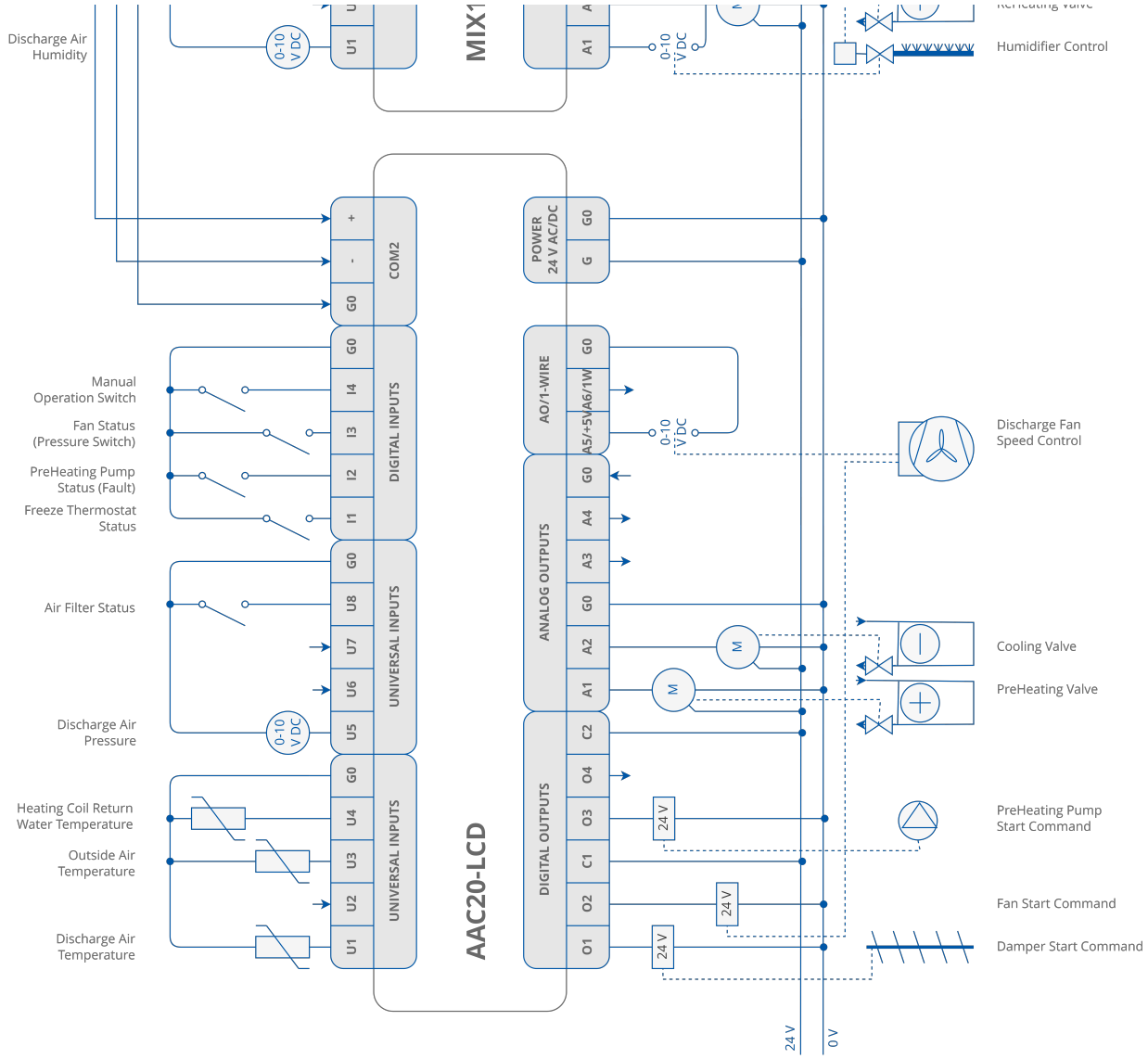


Figure 84. Electrical connections for supply air handling unit with water heaters, water cooler, and humidification and dehumidification function

8.3 Example 3

8.3.1 Supply and Exhaust Air Handling Unit with Water Heater (and, Optionally, Water Cooler)

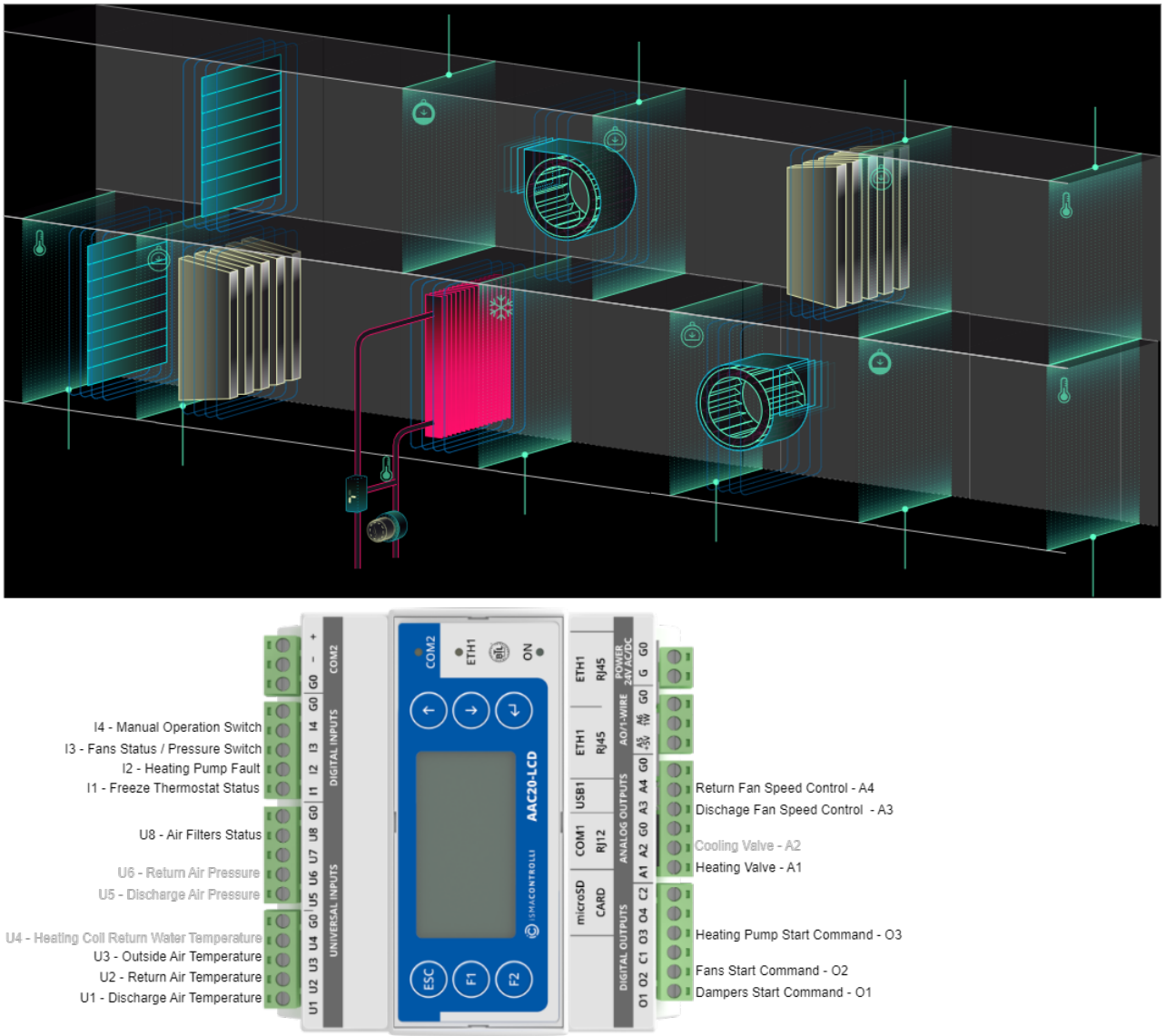


Figure 85. Inputs and outputs configured for supply and exhaust air handling unit with water heater (and, optionally, water cooler)

The air handling unit consists of:

- 2-position inlet and outlet damper;
- air supply and exhaust filter;
- water heater with a valve and a heater pump;
- supply and exhaust fans controlled by an inverter.

The required sensors/signals are:

- discharge air temperature sensor;
- return air temperature sensor;
- anti-freeze thermostat;
- fans operating status (pressure switch, signal from the inverter) – connected in series;
- manual switch control (permission to operate the ventilation system)

Some of the useful sensors/signals, optional but not required:

- heater pump failure status;
- filters dirty status (for monitoring only) – connected in parallel.

In addition, the system can be equipped with extra sensors/signals, such as:

- outside air temperature;
- heater return water temperature;
- discharge air pressure sensor (only when there is a need to maintain constant pressure on the supply duct);
- return air pressure sensor (only when there is a need to maintain constant pressure on the exhaust duct).

The application allows for:

- controlling the opening/closing of the 2-position inlet and outlet damper;
- the fans to start and controlling their speed (constant or pressure dependent);
- controlling the modulating (analog 0-10 V DC) heater valve actuator and the heater pump.

In addition, if a water cooler is also configured, it will also be controlled by the modulating (analog 0-10 V DC) cooler valve actuator (and here an outside air temperature sensor is required – i.e. to disable using a cooler in the winter).

AHU Configuration example:

- heater mode – **Heater [1]**
- energy recovery mode – **None [0]**
- cooler mode – **None or Cooler [0 or 1]** (depending on the need)
- humidifier mode – **None [0]**
- economizer mode – **None [0]**
- temperature control mode – **Cascade Temp, Constant Disch Temp or Comfort Zone Temp [1, 2 or 3]** (depending on the need)
- humidity control mode – n/a

8.3.2 Application Algorithm Description

Start-up

1. The first step after configuring the application for a particular type of the AHU is to make sure that the time schedule is correctly configured, which allows the AHU to run in a normal mode (Plant Mode as Occupied Period [4]) or in a night mode (with reduced efficiency - Plant Mode as Night Cycle [2]). If not, the time schedule must first be set correctly to allow a proper AHU operation.
2. The signal that allows the AHU to start is the signal connected to the I4 input of the AAC20 (Operating Switch). Activating this signal (physical short circuit at the input) and correctly setting the time schedule allows the AHU to start, while deactivating the signal automatically stops the AHU.

Preheater

1. The next step before starting the AHU is for the controller to verify that the heater has no active alarm conditions associated with the antifreeze protection procedure.

2. The antifreeze protection of the heater is used in the winter period (when the outside temperature is lower than the limit set by OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K).
3. The basic element is the antifreeze thermostat whose physical setting should be in accordance with or slightly lower than the above limit (e.g., by 1°C). The antifreeze thermostat is connected to the I1 input on the AAC20 controller (Freeze Thermostat Status).
4. Activation of the antifreeze thermostat (physical short circuit at the input) triggers the antifreeze protection procedure consisting of stopping the AHU (turning off the fans and closing the dampers), opening the heater valve at output A1 of the AAC20 (Heating Valve) to the level specified in HTV_FrostProt_ValveUp (by default, 100%), and switching on the heater pump at output O3 (Heating Pump Start Command) if configured for use by HPU_Enable (by default, active - true).
5. An additional element of antifreeze protection is the use of a return water temperature sensor connected to the U4 input in the AAC20 (Heating Coil Return Water Temperature). If the antifreeze thermostat is triggered, the setpoint for the return water temperature is raised additionally by the level specified in FEZ_RWT_SptUp (by default, 15K).
6. When the temperature of the heater rises and the antifreeze thermostat returns to the normal state: in such case, if there is a sensor for the water temperature at the return from the heater, its setpoint will begin to fall at the rate of FEZ_SetupRamp (default 1K/min) to the normal setpoint (calculated on the basis of the outside temperature); if there is no sensor, the valve closes at the rate of HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current system control.
7. The heater return water temperature sensor also serves as a high limit for the water temperature in the heater by closing the valve if the temperature specified in RWT_MaxSetpoint is too high (85°C by default).
8. If the pump is activated in HPU_Enable (active by default - true) and connected to the O3 output in the AAC20 (Heating Pump Start Command), it is switched on with the delay HPU_OnDelay (by default, 5 s) when the heater valve connected to the A1 output in the AAC20 (Heating Valve) opens to 3% or more, and switched off with the delay specified in HPU_OffDelay (by default, 300 s) when the valve is open 1% or less.
9. In winter, the pump is permanently activated if the outside temperature falls below the OAT_FrostProtection limit (by default, 6°C) with a central hysteresis of 1K and if the antifreeze thermostat is activated.
10. When using the pump failure signal, which is connected to the I2 input on the AAC20 (Heating Pump Fault), and when the value in HPU_StatusAlarmDelay (by default, 1 s) is set to default, then in the winter period the AHU can be turned off if:
    a. DME_EmergencyStop (deactivated by default - false) is active (set to true),
    b. an alarm is generated on the O2 output of the MIX18 module (Heat Pumps Failure Alarm), and
    c. the pump control output is turned off.
    The alarm is automatically reset if the signal at the input is deactivated and the pump and AHU system resume operation (if stopped).
11. An additional feature to ensure a proper and long-lasting operation of the devices operating the heater is exercising the pump and valve. First, the pump is exercised, then the valve, which, by default, takes place every Sunday at 1am in case they are not in use. The exercise consists of turning on the pump for the time specified in

HPU_Pmp_Vlv_Exercise (120 s by default) and then opening the valve to 100% for the same time as above.

Dampers

1. In winter, when the outside temperature is lower than the limit specified by OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K and the return water temperature sensor is used, then, it must reach the setpoint (calculated from the outside temperature) to allow the dampers to open after the time specified in DME_OnDelay (by default, 300 s).
2. If the return water temperature sensor from the heater is not used, the damper is opened only after the time specified in DME_OnDelay (by default, 300 s), during which the valve is opened according to the HTV_FrostProt_ValveUp parameter (by default, 100%) and drops at the rate specified by HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current system control.
3. When the outside temperature is above the limit specified in OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K (summer period), the dampers are opened without the delay specified in DME_OnDelay (by default, 300 s) and the heater return water temperature is not controlled at that time.
4. The dampers connected to the O1 output in the AAC20 (Dampers Start Command) opens after the time specified in DME_OnDelay (by default, 300 s) only after the permission from the normally operating heater, and then the signal from the dampers are transmitted as a start permission for the fans with a delay of MAD_RunTime (by default, 150 s).

Fans

1. If pressure sensors is connected at the U5 and U6 input in the AAC20 (Discharge Air Pressure, Return Air Pressure), each fan in is controlled smoothly connected at the A3 or A4 output in the AAC20 (Discharge Fan Speed Control, Return Fan Speed Control) in the range from FSC_MinSignal (by default, 30%) to FCS_MaxSignal (by default, 100%) so as to maintain the set pressures, or is controlled from the control signal resulting from humidity or manually with a set speed in the above ranges in the absence of connected pressure sensors (the higher control value is selected).
2. Each fan has its preset DischPressSpt pressure (500 Pa by default) and ReturnPressSpt (500 Pa by default), which it is supposed to maintain by adjusting its speed accordingly.
3. Fans connected to the O2 output in the AAC20 (Fans Start Command) start with the delay specified in FSC_OffOnDelay (by default, 5 s) after receiving a permission from the dampers.
4. After receiving the startup permission, the fan speed control signal slowly ramps up at the rate of FSC_Ramp (by default, 1%/min) to the desired value resulting from the corresponding control as indicated above. The rate of rise or fall of the control signal is determined by the same speed.
5. The pressure setpoint behaves similarly, which during the AHU startup ramps up from zero to the desired setpoint at the speed of DSP_PressSptRamp (by default, 50 Pa/min). If it is changed during a normal operation, it will correspondingly start falling or rising at the same speed specified in DSP_PresSptRamp (by default, 50 Pa/min).
6. For a night mode, the set pressure is reduced by multiplying it by the DSP_NightReduce factor (by default, 50%).

7. To protect the fans operation, a fans confirmation signal is connected to the I3 input in the AAC20 (Fans Status/Pressure Switch), which if not activated by the time FDP_BeltAlarmDelay (default 120s), then, an alarm is generated on the O1 output of MIX18 (Fans Failure Alarm) and this causes the AHU to stop. This function can be disabled by setting the zero value in FDP_BeltAlarmDelay (by default, 120 s).
8. In the automatic reset mode specified in FSC_ManualReset (by default, false), after an alarm from the fan, the alarm will be reset and the AHU will resume operation, while after three unsuccessful attempts to start, the system stops and in the automatic mode it can be reset by removing and reactivating the I4 input in AAC20 (Operating Switch). While if the manual reset mode specified in FSC_ManualReset (deactivated - false by default) is set to true, after an alarm from the fan the AHU will be stopped and the controller will wait for a reset signal activated by the input connected to the I5 input in MIX18 (Reset) and only then will it attempt to restart the AHU.

Control

1. In winter, during the AHU startup, the temperature control system temporarily raises the setpoint for the discharge temperature by an additional value specified in DAT_SptRamp (by default, 1K) which drops in time specified in DAT_SptDecTime (by default, 600 s).
2. The application allows to configure the TempCtrlMode temperature control function in 3 modes described below.
3. The cascade control function consists of regulating the discharge temperature connected to the U1 input of the AAC20 (Discharge Air Temperature), whose setpoint is determined by the control loop of the return temperature connected to the U2 input of the AAC20 (Return Air Temperature) and the setpoint of the return temperature TempSpt (by default, 22°C) in the heating or cooling function, as well as the fan speed allowing the fans to run above the value derived from RT_DATSpt_shift (by default, 60%), as long as pressure control is not used and the manual setting is lower than that derived from the temperature control function.
4. The fixed-value temperature control function consists of adjusting the discharge air temperature connected at the U1 input of the AAC20 controller (Discharge Air Temperature) based on the set TempSpt temperature (by default, 22°C), and based on the control loop the control level for the heater or cooler is calculated.
5. The cascade control function with comfort zone consists of adjusting the discharge air temperature connected at the U1 input U1 of the AAC20 (Discharge Air Temperature) to achieve a set discharge air temperature separate for the heating and cooling functions, taking into account the RT_ComfortZone comfort zone between them (the optimal zone in which heating and cooling are not adjusted – by default, 2°C). The setpoint of discharge temperature is the output from the return temperature control system connected to the U2 input of the AAC20 controller (Return Air Temperature) to achieve the set temperature defined by the TempSpt variable (default 22°C). In addition, the discharge air temperature control system can affect the speed of the fans by allowing them to run above the value derived from RT_DATSpt_shift (by default, 60%), unless pressure control is used or the manual speed setting is lower than that derived from the discharge air temperature control function.
6. The setpoint of discharge temperature is calculated from DAT_LowSetpoint (by default, 14°C) to DAT_HighSetpoint (by default, 26°C).
7. If the discharge temperature falls below the low limit, the cooler is gradually closed, and then the heater begins to open.

8. If the discharge temperature rises above the high limit, the heater is gradually closed, and then the cooler begins to open.
9. The TempSpt set temperature (by default, 22°C) can take into account the winter compensation specified by the WC_DischSptRaise parameter (by default, 4K) or the summer compensation specified by the SC_DischSptRaise parameter (by default, 4K).
10. In the case of a night temperature drop, the RT_ComfortZone comfort zone is expanded four times.
11. In summer, if the outside temperature rises above the OAT_HeaterLimit (by default, 20°C), heater control is blocked, and in winter, if the outside temperature falls below the OAT_CoolerLimit (by default, 14°C), cooler control is blocked.
12. When the antifreeze protection is triggered, all control signals are reset except for the signal for the heater which is set to the level specified in HTV_FrostProt_ValveUp (by default, 100%). When the risk of freezing ceases, all signals return to normal operation.
13. The heater valve is opened or closed by the valve actuator according to the control signal coming from the temperature control system according to the configured TempCtrlMode.

Cooler

1. When cooling is needed, the cooler valve connected to the A2 output (Cooling Valve) opens based on a signal coming from the temperature control system.
2. The control of the cooler valve is blocked below the OAT_CoolerLowLimit temperature (by default, 14°C) with a central hysteresis of 1K.
3. During the AHU startup and each time the valve is opened from zero, the control signal gradually increases at the rate specified in CCV_VlvRamp (by default, 5%/min).
4. To protect against too low air temperature behind the cooler, it is possible to use a temperature sensor connected to the U3 input on the MIX18 module (Cooling Limit Air Temperature) causing the cooler valve to gradually close when the temperature drops to the LIM_Setpoint value (by default, 14°C).
5. An additional feature to ensure a proper and long-lasting operation of the cooler is exercising the valve. It is carried out by default every Sunday at 1am in case it is not being used. Exercise consists of opening the valve to 100% for the time specified in CCV_Vlv_Exercise (120 s by default).

8.3.3 Electrical Connections

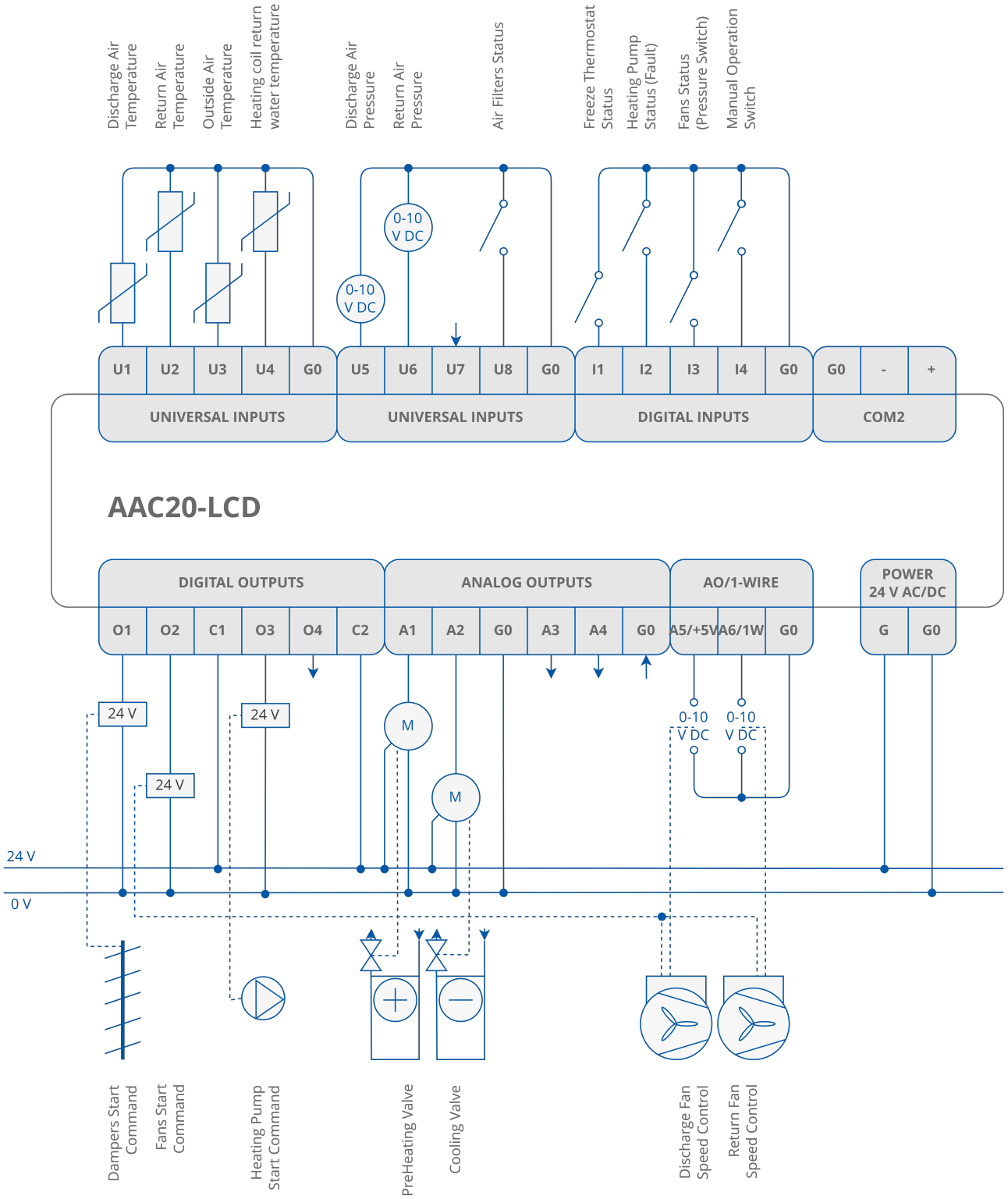


Figure 86. Electrical connections for supply and exhaust air handling unit with water heater (and, optionally, water cooler)

8.4 Example 4

8.4.1 Supply and Exhaust Air Handling Unit with Water Heaters and Water Cooler, with Humidification and Dehumidification Function

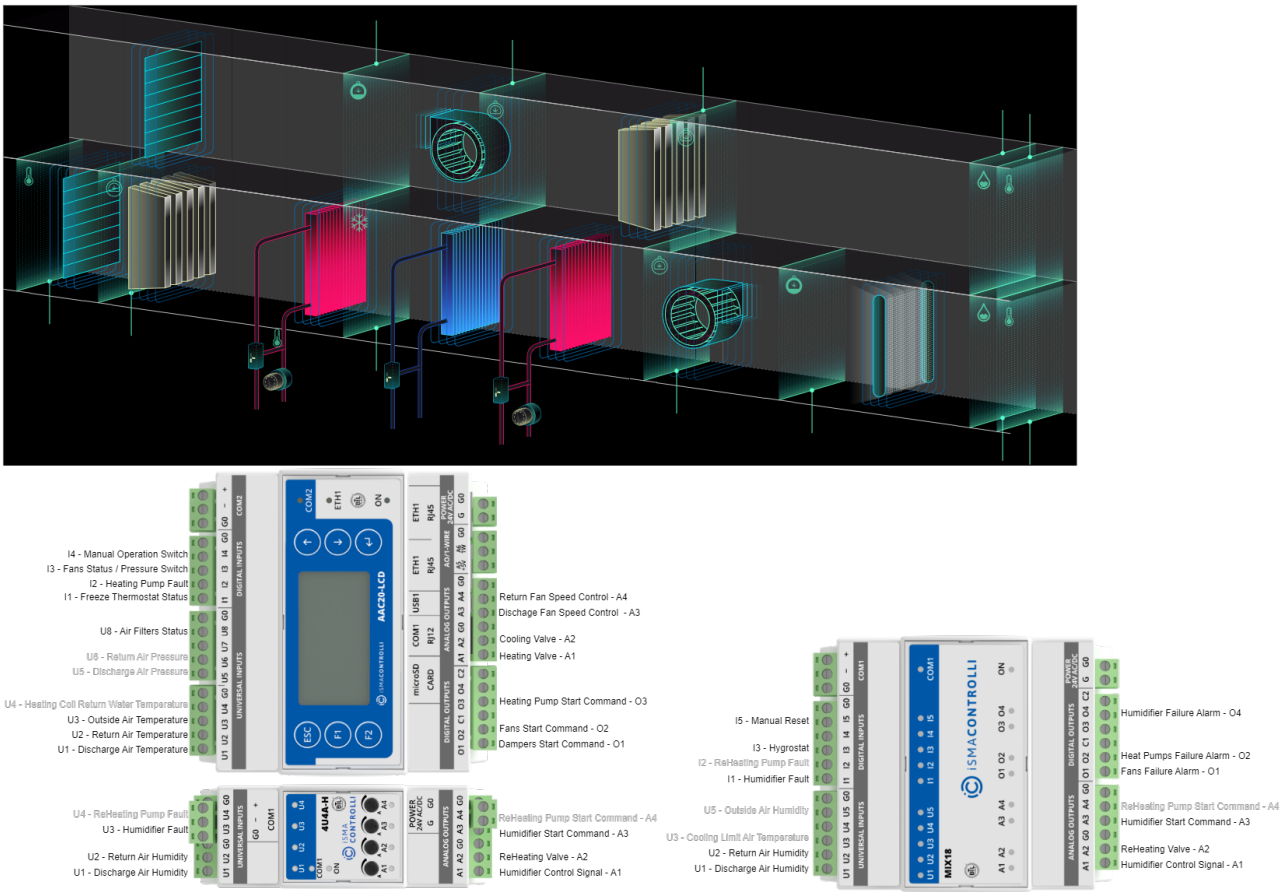


Figure 87. Inputs and outputs configured for supply and exhaust air handling unit with water heaters and water cooler, with humidification and dehumidification function

The air handling unit consists of:

- 2-position inlet and outlet damper;
- air supply and exhaust filter;
- water preheater with a valve and a preheater pump;
- water cooler with a valve;
- water reheater with a valve and, optionally, a reheater pump;
- supply and exhaust fans controlled by an inverter;
- humidifier.

To enable humidity control in the humidification and dehumidification function, it is required to add an additional extension I/O module, iSMA-B-4U4A or -MIX18, to the AAC20 controller (depending on the demand and required sensors/signals).

The required sensors/signals are:

- discharge air temperature sensor;
- return air temperature sensor;
- discharge air humidity sensor;
- return air humidity sensor;

- anti-freeze thermostat;
- humidifier failure status (can be used in conjunction with a hygrostat for the MINI module);
- hygrostat (if is required and installed);
- fans operating status (pressure switch, signal from the inverter) – connected in series;
- manual switch control (permission to operate the ventilation system).

Some of the useful sensors/signals, optional but not required:

- preheat pump failure status;
- reheat pump failure status (if installed);
- filters dirty status (for monitoring only) – connected in parallel;
- manual reset (for MIX18 only, in case of manual fault reset).

In addition, the system can be equipped with extra sensors/signals, such as:

- outside air temperature;
- outside air humidity;
- heater return water temperature;
- cooler limit air temperature;
- discharge air pressure sensor (only when there is a need to maintain constant pressure on the supply duct);
- return air pressure sensor (only when there is a need to maintain constant pressure on the exhaust duct).

The application allows for:

- controlling the opening/closing of the 2-position inlet and outlet dampers;
- the fans to start and controlling their speed (constant or pressure dependent);
- controlling the modulating (analog 0-10 V DC) preheater valve actuator and the preheater pump;
- controlling the modulating (analog 0-10 V DC) reheater valve actuator (used for the dehumidification function) and, optionally, the reheater pump;
- controlling the modulating (analog 0-10 V DC) cooler valve actuator;
- allowing the humidifier to start and controlling its humidification performance.

If the MIX18 module is used, it is also possible to signal alarm states for the fans (common alarm), heaters pump (common alarm), and humidifier.

AHU configuration example:

- heater mode – **PreHeater & ReHeater [2]**
- energy recovery mode – **None [0]**
- cooler mode – **Cooler [1]**
- humidifier mode – **Water Humidifier or Steam Humidifier [1 or 2]** (depending on the need)
- economizer mode – **None [0]**
- temperature control mode – **Cascade Temp, Constant Disch Temp or Comfort Zone Temp [1, 2 or 3]** (depending on the need)
- humidity control mode – **Comfort Hum, Return Hum, Disch Abs Hum or Constant Disch Abs Hum [1, 2, 3 or 4]** (depending on the need)

8.4.2 Application Algorithm Description

Start-up

1. The first step after configuring the application for a particular type of the AHU is to make sure that the time schedule is correctly configured, which allows the AHU to run in a normal mode (Plant Mode as Occupied Period [4]) or in a night mode (with reduced efficiency - Plant Mode as Night Cycle [2]). If not, the time schedule must first be set correctly to allow a proper AHU operation.
2. The signal that allows the AHU to start is the signal connected to the I4 input of the AAC20 (Operating Switch). Activating this signal (physical short circuit at the input) and correctly setting the time schedule allows the AHU to start, while deactivating the signal automatically stops the AHU.

Preheater

1. The next step before starting the AHU is for the controller to verify that the heater has no active alarm conditions associated with the antifreeze protection procedure.
2. The antifreeze protection of the heater is used in the winter period (when the outside temperature is lower than the limit set by OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K).
3. The basic element is the antifreeze thermostat whose physical setting should be in accordance with or slightly lower than the above limit (e.g., by 1°C). The antifreeze thermostat is connected to the I1 input on the AAC20 controller (Freeze Thermostat Status).
4. Activation of the antifreeze thermostat (physical short circuit at the input) triggers the antifreeze protection procedure consisting of stopping the AHU (turning off the fans and closing the dampers), opening the heater valve at output A1 of the AAC20 (Heating Valve) to the level specified in HTV_FrostProt_ValveUp (by default, 100%), and switching on the heater pump at output O3 (Heating Pump Start Command) if configured for use by HPU_Enable (by default, active - true).
5. An additional element of antifreeze protection is the use of a return water temperature sensor connected to the U4 input in the AAC20 (Heating Coil Return Water Temperature). If the antifreeze thermostat is triggered, the setpoint for the return water temperature is raised additionally by the level specified in FEZ_RWT_SptUp (by default, 15K).
6. When the temperature of the heater rises and the antifreeze thermostat returns to the normal state: in such case, if there is a sensor for the water temperature at the return from the heater, its setpoint will begin to fall at the rate of FEZ_SetupRamp (default 1K/min) to the normal setpoint (calculated on the basis of the outside temperature); if there is no sensor, the valve closes at the rate of HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current system control.
7. The heater return water temperature sensor also serves as a high limit for the water temperature in the heater by closing the valve if the temperature specified in RWT_MaxSetpoint is too high (85°C by default).
8. If the pump is activated in HPU_Enable (active by default - true) and connected to the O3 output in the AAC20 (Heating Pump Start Command), it is switched on with the delay HPU_OnDelay (by default, 5 s) when the heater valve connected to the A1 output

in the AAC20 (Heating Valve) opens to 3% or more, and switched off with the delay specified in HPU_OffDelay (by default, 300 s) when the valve is opened 1% or less.

9. In winter, the pump is permanently activated if the outside temperature falls below the OAT_FrostProtection limit (by default, 6°C) with a central hysteresis of 1K and if the antifreeze thermostat is activated.
10. When using the pump failure signal, which is connected to the I2 input on the AAC20 (Heating Pump Fault), and when the value in HPU_StatusAlarmDelay (by default, 1 s) is set to default, then in the winter period the AHU can be turned off if:
    a. DME_EmergencyStop (deactivated by default - false) is active (set to true),
    b. an alarm is generated on the O2 output of the MIX18 module (Heat Pumps Failure Alarm), and
    c. the pump control output is turned off.
    The alarm is automatically reset if the signal at the input is deactivated and the pump and AHU system resume operation (if stopped).
11. An additional feature to ensure a proper and long-lasting operation of the devices operating the heater is exercising the pump and valve. First, the pump is exercised, then the valve, which, by default, takes place every Sunday at 1am in case they are not in use. The exercise consists of turning on the pump for the time specified in HPU_Pmp_Vlv_Exercise (120 s by default) and then opening the valve to 100% for the same time as above.

Dampers

1. In winter, when the outside temperature is lower than the limit specified by OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K and the return water temperature sensor is used, then, it must reach the setpoint (calculated from the outside temperature) to allow the dampers to open after the time specified in DME_OnDelay (by default, 300 s).
2. If the return water temperature sensor from the heater is not used, the damper is opened only after the time specified in DME_OnDelay (by default, 300 s), during which the valve is opened according to the HTV_FrostProt_ValveUp parameter (by default, 100%) and drops at the rate specified by HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current system control.
3. When the outside temperature is above the limit specified in OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K (summer period), the dampers are opened without the delay specified in DME_OnDelay (by default, 300 s) and the heater return water temperature is not controlled at that time.
4. The dampers connected to the O1 output in the AAC20 (Dampers Start Command) open after the time specified in DME_OnDelay (by default, 300 s) only after the permission from the normally operating heater, and then the signal from the dampers are transmitted as a start permission for the fans with a delay of MAD_RunTime (by default, 150 s).

Fans

1. If pressure sensors is connected at the U5 and U6 input in the AAC20 (Discharge Air Pressure, Return Air Pressure), each fan in is controlled smoothly connected at the A3 or A4 output in the AAC20 (Discharge Fan Speed Control, Return Fan Speed Control) in the range from FSC_MinSignal (by default, 30%) to FCS_MaxSignal (by default, 100%) so as to maintain the set pressures, or is controlled from the control signal resulting from

humidity or manually with a set speed in the above ranges in the absence of connected pressure sensors (the higher control value is selected).
2. Each fan has its preset DischPressSpt pressure (500 Pa by default) and ReturnPressSpt pressure (500 Pa by default), which it is supposed to maintain by adjusting its speed accordingly.
3. Fans connected to the O2 output in the AAC20 (Fans Start Command) start with the delay specified in FSC_OffOnDelay (by default, 5 s) after receiving a permission from the dampers.
4. After receiving the startup permission, the fan speed control signal slowly ramps up at the rate of FSC_Ramp (by default, 1%/min) to the desired value resulting from the corresponding control as indicated above. The rate of rise or fall of the control signal is determined by the same speed.
5. The pressure setpoint behaves similarly, which during the AHU startup ramps up from zero to the desired setpoint at the speed of DSP_PressSptRamp (by default, 50 Pa/min). If it is changed during a normal operation, it will correspondingly start falling or rising at the same speed specified in DSP_PresSptRamp (by default, 50 Pa/min).
6. For a night mode, the set pressure is reduced by multiplying it by the DSP_NightReduce factor (by default, 50%).
7. To protect the fans operation, a fans confirmation signal is connected to the I3 input in the AAC20 (Fans Status/Pressure Switch), which if not activated by the time FDP_BeltAlarmDelay (default 120s), then, an alarm is generated on the O1 output of MIX18 (Fans Failure Alarm) and this causes the AHU to stop. This function can be disabled by setting the zero value in FDP_BeltAlarmDelay (by default, 120 s).

Control

1. In the automatic reset mode specified in FSC_ManualReset (by default, false), after an alarm from the fan, the alarm will be reset and the AHU will resume operation, while after three unsuccessful attempts to start, the system stops and in the automatic mode it can be reset by removing and reactivating the I4 input in AAC20 (Operating Switch). While in the manual reset mode specified in FSC_ManualReset (deactivated - false by default) is set to true, after an alarm from the fan the AHU will be stopped and the controller will wait for a reset signal activated by the input connected to the I5 input in MIX18 (Reset) and only then will it attempt to restart the AHU.
2. In winter, during the AHU startup, the temperature control system temporarily raises the setpoint for the discharge temperature by an additional value specified in DAT_SptRamp (by default, 1K) which drops in time specified in DAT_SptDecTime (by default, 600 s).
3. The application allows to configure the TempCtrlMode temperature control function in 3 modes described below.
4. The cascade control function consists of regulating the discharge temperature connected to the U1 input of the AAC20 (Discharge Air Temperature), whose setpoint is determined by the control loop of the return temperature connected to the U2 input of the AAC20 (Return Air Temperature) and the setpoint of the return temperature TempSpt (by default, 22°C) in the heating or cooling function, as well as the fan speed allowing the fans to run above the value derived from RT_DATSpt_shift (by default, 60%), as long as pressure control is not used and the manual setting is lower than that derived from the temperature control function.
5. The fixed-value temperature control function consists of adjusting the discharge air temperature connected at the U1 input of the AAC20 controller (Discharge Air

Temperature) based on the set TempSpt temperature (by default, 22°C), and based on the control loop the control level for the heater or cooler is calculated.

6. The cascade control function with comfort zone consists of adjusting the discharge air temperature connected at the U1 input U1 of the AAC20 (Discharge Air Temperature) to achieve a set discharge air temperature separate for the heating and cooling functions, taking into account the RT_ComfortZone comfort zone between them (the optimal zone in which heating and cooling are not adjusted – by default, 2°C). The setpoint of discharge temperature is the output from the return temperature control system connected to the U2 input of the AAC20 controller (Return Air Temperature) to achieve the set temperature defined by the TempSpt variable (default 22°C). In addition, the discharge air temperature control system can affect the speed of the fans by allowing them to run above the value derived from RT_DATSpt_shift (by default, 60%), unless pressure control is used or the manual speed setting is lower than that derived from the discharge air temperature control function.
7. The setpoint of discharge temperature is calculated from DAT_LowSetpoint (by default, 14°C) to DAT_HighSetpoint (by default, 26°C).
8. If the discharge temperature falls below the low limit, the cooler is gradually closed, and then the heater begins to open.
9. If the discharge temperature rises above the high limit, the heater is gradually closed, and then the cooler begins to open.
10. The TempSpt set temperature (by default, 22°C) can take into account the winter compensation specified by the WC_DischSptRaise parameter (by default, 4K) or the summer compensation specified by the SC_DischSptRaise parameter (by default, 4K).
11. In the case of a night temperature drop, the RT_ComfortZone comfort zone is expanded four times.
12. In the case of active humidification function, the fans speed can gradually increase with the humidifier control signal, as long as pressure control is not used and the manual setting is lower than the humidification control function.
13. When the absolute humidity outside is higher than that of the return, the sequence changes, causing the cooler to open first, and then increase the speed of the fans (with a note as above).
14. In summer, if the outside temperature rises above the OAT_HeaterLimit (by default, 20°C), heater control is blocked, and in winter, if the outside temperature falls below the OAT_CoolerLimit (by default, 14°C), cooler control is blocked.
15. When the antifreeze protection is triggered, all control signals are reset except for the signal for the heater which is set to the level specified in HTV_FrostProt_ValveUp (by default, 100%). When the risk of freezing ceases, all signals return to normal operation.
16. The heater valve is opened or closed by the valve actuator according to the control signal coming from the temperature control system according to the configured TempCtrlMode.

Reheater

1. When HeaterMode (mode 2) is selected as operation mode for both primary and secondary heaters, then when the humidification function is active, only the primary heater works, and when the dehumidification function is in operation, only the secondary heater is used for temperature control.
2. If no humidity control is used (or no active humidification or dehumidification function), both heaters work simultaneously in the temperature control function, but

can be configured as needed for gradual operation (the primary heater is the first stage, and the secondary is the second).
3. If the secondary heater pump is activated in HPU_Enable (active by default - true) and connected to the A4 output of the module 4U4A-H or MIX18 (ReHeating Pump Start Command), it is switched on with the delay HPU_OnDelay (by default, 5 s) when the secondary heater valve connected to the A2 output in the module 4U4A-H or MIX18 (ReHeating Valve) opens to 3% or more, and is switched off with the delay specified in HPU_OffDelay (by default, 300 s) when the valve is opened 1% or less.
4. In winter, when the outdoor temperature drops below the OAT_FrostProtection value (by default, 6°C) at the start of the AHU system, the secondary heater valve opens according to the HTV_FrostProt_ValveUp parameter (by default, 100%) and drops at the rate specified by HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current system control.
5. In winter, the secondary heater pump is permanently activated if the outdoor temperature falls below the OAT_FrostProtection limit (by default, 6°C) with a central hysteresis of 1K.
6. When using the secondary heater pump failure signal which is connected to the U4 input of the module 4U4A-H or the I2 input of the module MIX18 (ReHeating Pump Fault) and when the value in HPU_StatusAlarmDelay (by default, 1 s) is set to default, an alarm is generated on the O2 output of the module MIX18 (Heat Pumps Failure Alarm) and the pump control output is disabled. The alarm is automatically reset if the input signal is deactivated and the pump resumes operation.
7. An additional feature to ensure a proper and long-lasting operation of the devices operating the secondary heater is exercising the pump and valve. First, the pump is exercised, then the valve, which, by default, takes place every Sunday at 1am in case they are not in use. The exercise consists of turning on the pump for the time specified in HPU_Pmp_Vlv_Exercise (120 s by default) and then opening the valve to 100% for the same time as above.

Cooler

1. When cooling is needed, the cooler valve connected to the A2 output (Cooling Valve) opens based on a stronger signal coming from the temperature control system or dehumidification function.
2. The control of the cooler valve is blocked below the OAT_CoolerLowLimit temperature (by default, 14°C) with a central hysteresis of 1K.
3. It is possible to block the control of the cooler valve in the humidification function with the CCV_CoolOnHumDisable parameter (active by default – true).
4. During the AHU startup and each time the valve is opened from zero, the control signal gradually increases at the rate specified in CCV_VlvRamp (by default, 5%/min).
5. To protect against too low air temperature behind the cooler, it is possible to use a temperature sensor connected to the U3 input on the MIX18 module (Cooling Limit Air Temperature) causing the cooler valve to gradually close when the temperature drops to the LIM_Setpoint value (by default, 14°C).
6. An additional feature to ensure a proper and long-lasting operation of the cooler is exercising the valve. It is carried out by default every Sunday at 1am in case it is not being used. Exercise consists of opening the valve to 100% for the time specified in CCV_Vlv_Exercise (120 s by default).

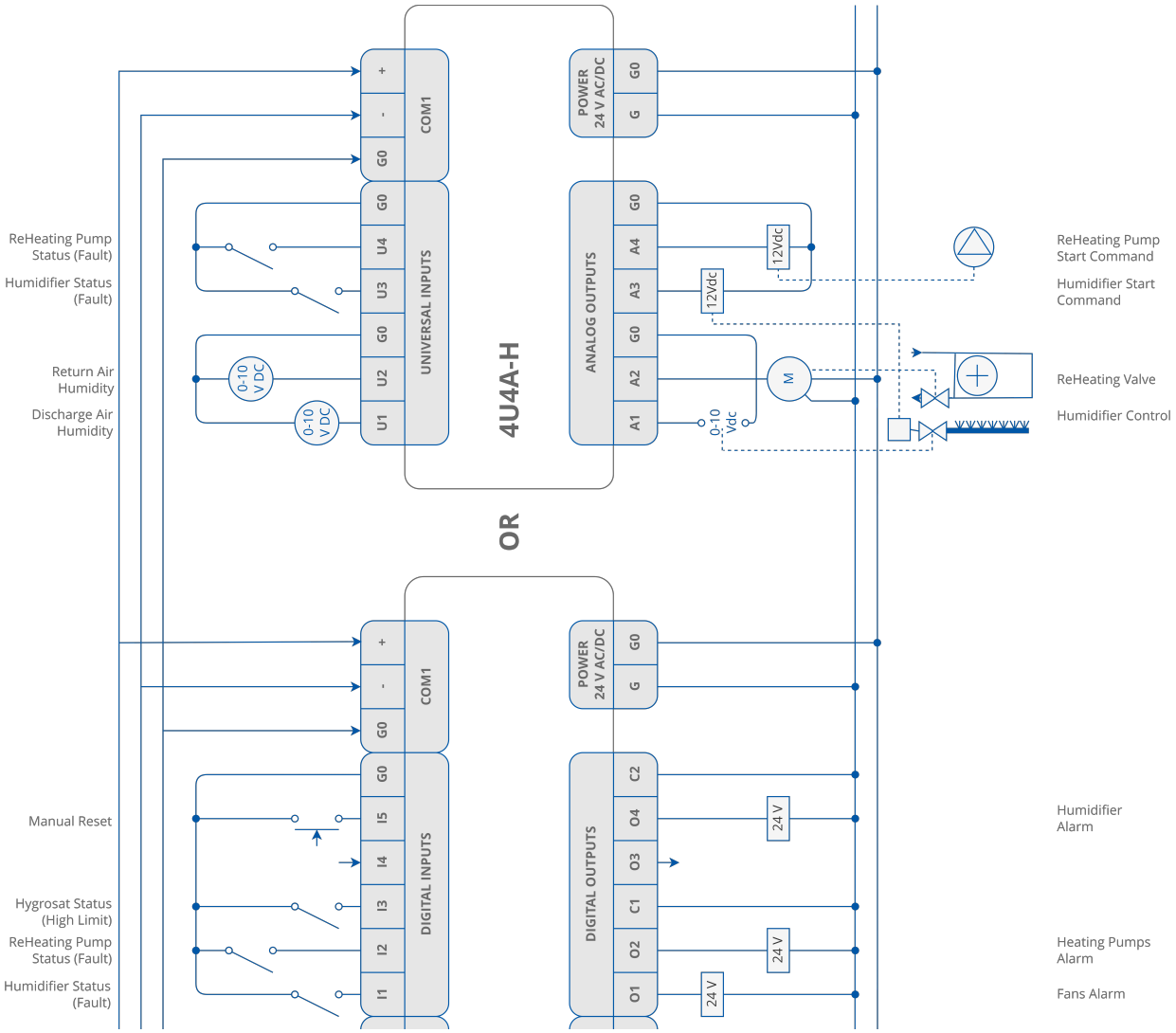
Humidifier

1. The AHU is also equipped with a humidification and dehumidification function. The humidification function is started with a delay of HUM_FanOnDelay (by default, 300 s) after confirming the operation of the fans connected to the I3 input in the AAC20 (Fans Status/Pressure Switch).
2. In case of lack of confirmation that the fans connected to the I3 input of the AAC20 (Fans Status/Pressure Switch) is operating, the humidification function is turned off immediately.
3. The humidification function is active when the outdoor temperature is lower than the OAT_HighHum parameter (by default, 14°C), and the dehumidification function is active when the outdoor temperature is higher than the OAT_LowDeh parameter (by default, 15°C).
4. To implement humidity control, a discharge air sensor connected to the U1 input of the 4U4A-H or MIX18 (Discharge Air Humidity) module and an return air sensor connected to the U2 input of the 4U4A-H or MIX 18 (Return Air Humidity) module are required, depending on the selected humidity control function.
5. The application allows to configure the HumCtrlMode humidity control function in 4 modes described below.
6. The function of return relative humidity control with comfort zone (optimal zone in which humidification and dehumidification control does not take place) is to regulate humidity so as to achieve HumSpt as the setpoint for return (by default, 55%) taking into account the comfort zone HUMDEH_ComfZone (by default, 4%) using humidification or dehumidification function. The comfort zone is quadrupled in the case of night temperature drop.
7. The function of controlling the return relative humidity without comfort zone is to adjust the humidity to achieve the HumSpt as the setpoint for the return (by default, 55%) using the humidification or dehumidification function.
8. The function of the discharge absolute humidity control is to adjust the humidity so as to achieve the discharge setpoint determined by the value from the return humidity sensor. The discharge humidity setpoint is calculated by the control loop, which is then used to regulate the discharge humidity using humidification or dehumidification functions. An absolute (not relative) humidity sensor connected on the discharge air is required to perform this function.
9. The function of the fixed-value absolute humidity discharge control is to adjust the humidity so as to achieve the HumSpt as the discharge setpoint (by default, 55%) using the humidification or dehumidification function. An absolute (not relative) humidity sensor connected on the discharge air is required to perform this function.
10. The humidity control function has two independent control loops, one for humidification control directly controlling the humidifier connected to the A1 output of the AAC20 controller (Humidifier Control Signal), and the other for dehumidification control affecting the control of the cooler connected to the A2 output of the AAC20 controller (Cooling Valve). The maintenance of the previously reduced temperature to the set level according to the temperature control is done by controlling the secondary heater connected to the A2 output of the 4U4A-H or MIX18 module (ReHeating Valve).
11. Both humidification and dehumidification control functions ramp up gradually at the speed of HUM_RampUp (by default, 10%/min) and DEH_RampUp (by default, 10%/min), respectively.
12. The HumSpt set humidity (by default, 55%) can take into account either winter compensation determined by a linear function in relation to the outside temperature

from RAH_MinHumSpt (by default, 30%Rh) to HumSpt (by default, 55%) or summer compensation determined by a linear function in relation to the outside temperature from HumSpt (by default, 55%) to RAH_MaxHumSpt (by default, 60%Rh).

13. Depending on the type of humidifier selected in HumidifierMode, the A3 output control in the 4U4A-H or MIX18 module (Humidifier Start Command) is activated as required: as a water humidifier pump (mode 1) or as switched on permanently (if there is no failure) during AHU operation as a steam humidifier enabler (mode 2).
14. In case of a humidifier failure activated at the U3 input of the 4U4A-H module or at the I1 input of the MIX18 module (Humidifier Fault), the humidifier control is turned off, the water humidifier pump/steam humidifier is shut down, and an alarm is generated at the O4 output of the MIX18 module (Humidifier Failure Alarm).
15. In addition to the hygrostat connected to the I3 input of the MIX 18 module (Hygrostat), which, when activated, turns off the humidification function (turns off the humidifier and pump / permit control), there is also a function to protect the occurrence of too much discharge humidity (to prevent the ducts from getting wet). If the discharge air humidity begins to increase towards the DAH_MaxSpt value (by default, 90%), then the humidifier control gradually decreases to zero.
16. Deactivation of the humidistat or humidifier failure automatically resets the alarm and returns to normal control mode.

8.4.3 Electrical Connections



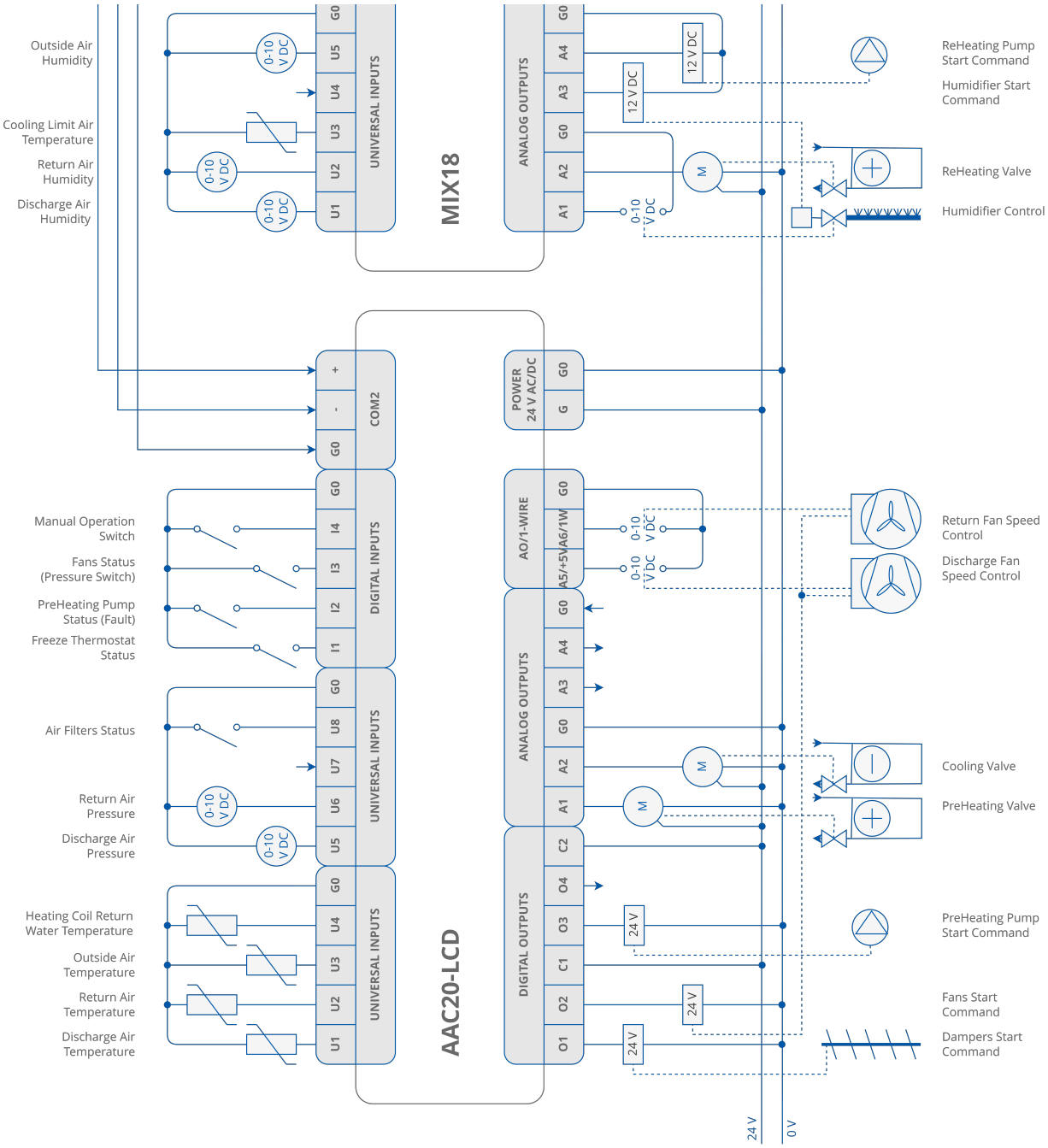


Figure 88. Electrical connections for supply and exhaust air handling unit with water heaters and water cooler, with humidification and dehumidification function

8.5 Example 5

8.5.1 Supply and Exhaust Air Handling Unit with Wheel Exchanger, Water Heaters and Water Cooler, with Humidification and Dehumidification Function

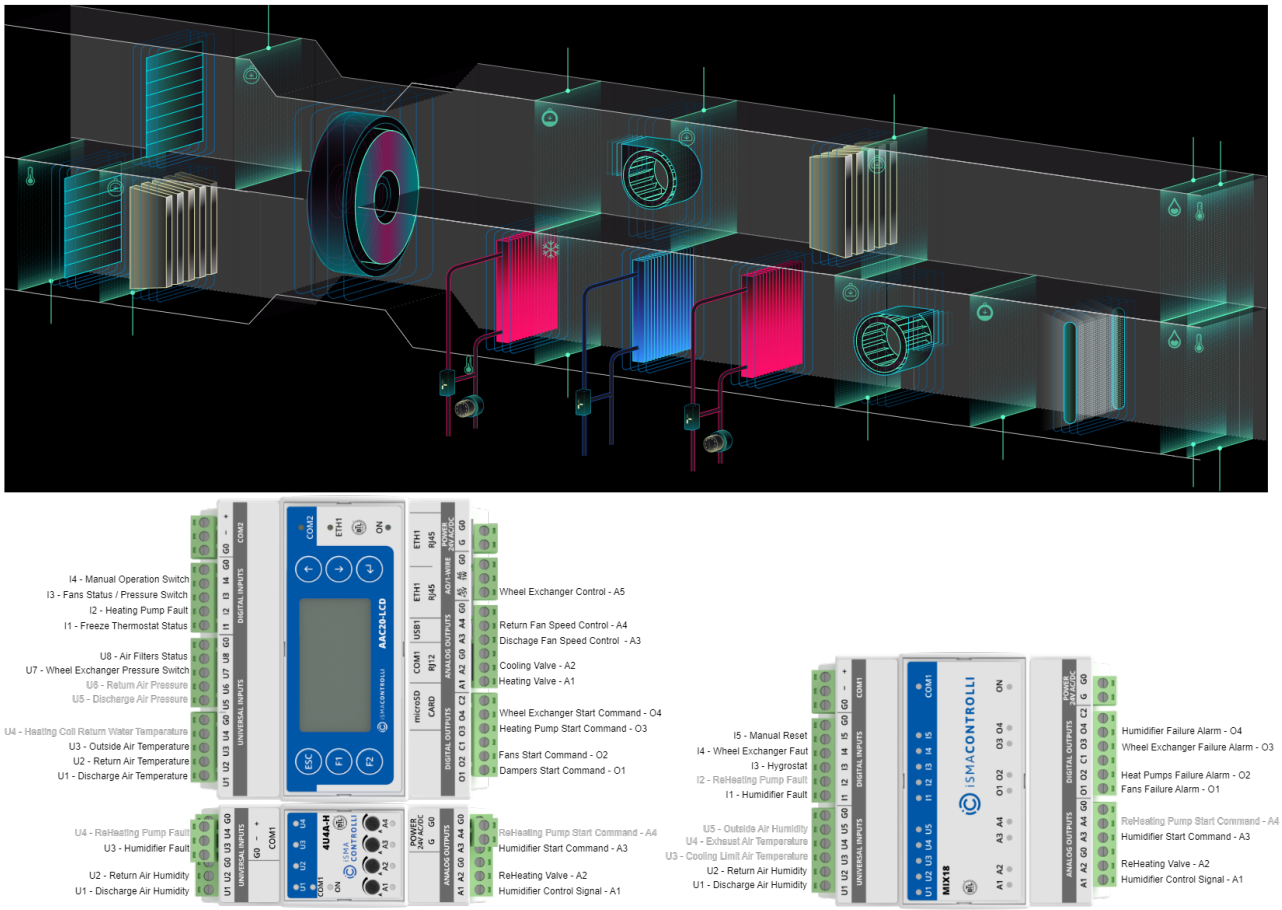


Figure 89. Inputs and outputs configured for supply and exhaust air handling unit with wheel exchanger, water heaters and water cooler, with humidification and dehumidification function

The air handling unit consists of

- 2-position inlet and outlet damper;
- air supply and exhaust filter;
- wheel exchanger;
- water preheater with a valve and a preheater pump;
- water cooler with a valve;
- water reheater with a valve and, optionally, a reheater pump;
- supply and exhaust fans controlled by an inverter;
- humidifier.

The AAC20 controller is sufficient if the dehumidification and humidification functions are not used. To enable humidity control, it is required to add an additional extension I/O module, iSMA-B-4U4A or -MIX18, to the AAC20 controller (depending on the demand and required sensors/signals).

The required sensors/signals are:

- discharge air temperature sensor;
- return air temperature sensor;

- outside air temperature sensor;
- wheel exchanger pressure switch or wheel exchanger exhaust air temperature (for MIX18 only);
- discharge air humidity sensor (for humidification and dehumidification functions);
- return air humidity sensor (for humidification and dehumidification functions);
- anti-freeze thermostat;
- humidifier failure status (can be used in conjunction with a hygrostat for the MINI module);
- hygrostat (if is required and is installed);
- fans operating status (pressure switch, signal from the inverter) – connected in series;
- manual switch control (permission to operate the ventilation system).

Some of the useful sensors/signals, optional but not required:

- preheat pump failure status;
- reheat pump failure status (if reheat pump is installed);
- wheel exchanger failure status (if required and is installed - for MIX18 only);
- filters dirty status (for monitoring only) – connected in parallel;
- manual reset (for MIX18 only, in case of manual fault reset).

In addition, the system can be equipped with extra sensors/signals, such as:

- outside air humidity;
- heater return water temperature;
- cooler limit air temperature;
- discharge air pressure sensor (only when there is a need to maintain constant pressure on the supply duct);
- return air pressure sensor (only when there is a need to maintain constant pressure on the exhausts duct).

The application allows for:

- controlling the opening/closing of the 2-position inlet and outlet dampers;
- the fans to start and controlling their speed (constant or pressure dependent);
- the wheel exchanger to start and controlling its speed;
- controlling the modulating (analog 0-10 V DC) preheater valve actuator and the preheater pump;
- controlling the modulating (analog 0-10 V DC) reheater valve actuator (used for the dehumidification function) and, optionally, the reheater pump;
- controlling the modulating (analog 0-10 V DC) cooler valve actuator;
- the humidifier to start and controlling its humidification performance.

If the MIX18 module is used, it is also possible to signal alarm states for the fans (common alarm), heaters pump (common alarm), wheel exchanger, and humidifier.

AHU configuration example:

- heater mode – **PreHeater & ReHeater [2]**
- energy recovery mode – **Wheel [1]**
- cooler mode – **Cooler [1]**
- humidifier mode – **Water Humidifier or Steam Humidifier [1 or 2]** (depending on the need)
- economizer mode – **None, Eco Return Temp or Eco Enthalpy [0, 1 or 2]** (depending on the need)

- temperature control mode – **Cascade Temp, Constant Disch Temp or Comfort Zone Temp [1, 2 or 3]** (depending on the need)
- humidity control mode – **Comfort Hum, Return Hum, Disch Abs Hum or Constant Disch Abs Hum [1, 2, 3 or 4]** (depending on the need)

8.5.2 Application Notes

Start-up

1. The first step after configuring the application for a particular type of the AHU is to make sure that the time schedule is correctly configured, which allows the AHU to run in a normal mode (Plant Mode as Occupied Period [4]) or in a night mode (with reduced efficiency - Plant Mode as Night Cycle [2]). If not, the time schedule must first be set correctly to allow a proper AHU operation.
2. The signal that allows the AHU to start is the signal connected to the I4 input of the AAC20 (Operating Switch). Activating this signal (physical short circuit at the input) and correctly setting the time schedule allows the AHU to start, while deactivating the signal automatically stops the AHU.

Preheater

1. The next step before starting the AHU is for the controller to verify that the heater has no active alarm conditions associated with the antifreeze protection procedure.
2. The antifreeze protection of the heater is used in the winter period (when the outside temperature is lower than the limit set by OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K).
3. The basic element is the antifreeze thermostat whose physical setting should be in accordance with or slightly lower than the above limit (e.g., by 1°C). The antifreeze thermostat is connected to the I1 input on the AAC20 controller (Freeze Thermostat Status).
4. Activation of the antifreeze thermostat (physical short circuit at the input) triggers the antifreeze protection procedure consisting of stopping the AHU (turning off the fans and closing the dampers), opening the heater valve at output A1 of the AAC20 (Heating Valve) to the level specified in HTV_FrostProt_ValveUp (by default, 100%), and switching on the heater pump at output O3 (Heating Pump Start Command) if configured for use by HPU_Enable (by default, active - true).
5. An additional element of antifreeze protection is the use of a return water temperature sensor connected to the U4 input in the AAC20 (Heating Coil Return Water Temperature). If the antifreeze thermostat is triggered, the setpoint for the return water temperature is raised additionally by the level specified in FEZ_RWT_SptUp (by default, 15K).
6. When the temperature of the heater rises and the antifreeze thermostat returns to the normal state: in such case, if there is a sensor for the water temperature at the return from the heater, its setpoint will begin to fall at the rate of FEZ_SetupRamp (default 1K/min) to the normal setpoint (calculated on the basis of the outside temperature); if there is no sensor, the valve closes at the rate of HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current system control.

7. The heater return water temperature sensor also serves as a high limit for the water temperature in the heater by closing the valve if the temperature specified in RWT_MaxSetpoint is too high (85°C by default).
8. If the pump is activated in HPU_Enable (active by default - true) and connected to the O3 output in the AAC20 (Heating Pump Start Command), it is switched on with the delay HPU_OnDelay (by default, 5 s) when the heater valve connected to the A1 output in the AAC20 (Heating Valve) opens to 3% or more, and switched off with the delay specified in HPU_OffDelay (by default, 300 s) when the valve is open 1% or less.
9. In winter, the pump is permanently activated if the outside temperature falls below the OAT_FrostProtection limit (by default, 6°C) with a central hysteresis of 1K and if the antifreeze thermostat is activated.
10. When using the pump failure signal, which is connected to the I2 input on the AAC20 (Heating Pump Fault), and when the value in HPU_StatusAlarmDelay (by default, 1 s) is set to default, then in the winter period the AHU can be turned off if:
    a. DME_EmergencyStop (deactivated by default - false) is active (set to true),
    b. an alarm is generated on the O2 output of the MIX18 module (Heat Pumps Failure Alarm), and
    c. the pump control output is turned off.
    The alarm is automatically reset if the signal at the input is deactivated and the pump and AHU system resume operation (if stopped).
11. An additional feature to ensure a proper and long-lasting operation of the devices operating the heater is exercising of the pump and valve. First, the pump is exercised, then the valve, which, by default, takes place every Sunday at 1am in case they are not in use. The exercise consists of turning on the pump for the time specified in HPU_Pmp_Vlv_Exercise (120 s by default) and then opening the valve to 100% for the same time as above.

Dampers

1. In winter, when the outside temperature is lower than the limit specified by OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K and the return water temperature sensor is used, then, it must reach the setpoint (calculated from the outside temperature) to allow the dampers to open after the time specified in DME_OnDelay (by default, 300 s).
2. If the return water temperature sensor from the heater is not used, the damper is opened only after the time specified in DME_OnDelay (by default, 300 s), during which the valve is opened according to the HTV_FrostProt_ValveUp parameter (by default, 100%) and drops at the rate specified by HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current system control.
3. When the outside temperature is above the limit specified in OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K (summer period), the dampers are opened without the delay specified in DME_OnDelay (by default, 300 s) and the heater return water temperature is not controlled at that time.
4. The dampers connected to the O1 output in the AAC20 (Dampers Start Command) open after the time specified in DME_OnDelay (by default, 300 s) only after the permission from the normally operating heater, and then the signal from the dampers are transmitted as a start permission for the fans with a delay of MAD_RunTime (by default, 150 s).

Fans

1. If pressure sensors is connected at the U5 and U6 input in the AAC20 (Discharge Air Pressure, Return Air Pressure), each fan in is controlled smoothly connected at the A3 or A4 output in the AAC20 (Discharge Fan Speed Control, Return Fan Speed Control) in the range from FSC_MinSignal (by default, 30%) to FCS_MaxSignal (by default, 100%) so as to maintain the set pressures, or is controlled from the control signal resulting from humidity or manually with a set speed in the above ranges in the absence of connected pressure sensors (the higher control value is selected).
2. Each fan has its preset DischPressSpt pressure (500 Pa by default) and ReturnPressSpt pressure (500 Pa by default), which it is supposed to maintain by adjusting its speed accordingly.
3. Fans connected to the O2 output in the AAC20 (Fans Start Command) start with the delay specified in FSC_OffOnDelay (by default, 5 s) after receiving a permission from the dampers.
4. After receiving the startup permission, the fan speed control signal slowly ramps up at the rate of FSC_Ramp (by default, 1%/min) to the desired value resulting from the corresponding control as indicated above. The rate of rise or fall of the control signal is determined by the same speed.
5. The pressure setpoint behaves similarly, which during the AHU startup ramps up from zero to the desired setpoint at the speed of DSP_PressSptRamp (by default, 50 Pa/min). If it is changed during a normal operation, it will correspondingly start falling or rising at the same speed specified in DSP_PresSptRamp (by default, 50 Pa/min).
6. For a night mode, the set pressure is reduced by multiplying it by the DSP_NightReduce factor (by default, 50%).
7. To protect the fans operation, a fans confirmation signal is connected to the I3 input in the AAC20 (Fans Status/Pressure Switch), which if not activated by the time FDP_BeltAlarmDelay (default 120s), then, an alarm is generated on the O1 output of MIX18 (Fans Failure Alarm) and this causes the AHU to stop. This function can be disabled by setting the zero value in FDP_BeltAlarmDelay (by default, 120 s).
8. In the automatic reset mode specified in FSC_ManualReset (by default, false), after an alarm from the fan, the alarm will be reset and the AHU will resume operation, while after three unsuccessful attempts to start the system stops and in the automatic mode it can be reset by removing and reactivating the I4 input in AAC20 (Operating Switch). While if the manual reset mode specified in FSC_ManualReset (deactivated - false by default) is set to true, after an alarm from the fan the AHU will be stopped and the controller will wait for a reset signal activated by the input connected to the I5 input in MIX18 (Reset) and only then will it attempt to restart the AHU.

Control

1. In winter, during the AHU startup, the temperature control system temporarily raises the setpoint for the discharge temperature by an additional value specified in DAT_SptRamp (by default, 1K) which drops in time specified in DAT_SptDecTime (by default, 600 s).
2. The application allows to configure the TempCtrlMode temperature control function in 3 modes described below.
3. The cascade control function consists of regulating the discharge temperature connected to the U1 input of the AAC20 (Discharge Air Temperature), whose setpoint is determined by the control loop of the return temperature connected to the U2

input of the AAC20 (Return Air Temperature) and the setpoint of the return temperature TempSpt (by default, 22°C) in the heating or cooling function (with the exchanger as the first stage in both cases or without), as well as the fan speed allowing the fans to run above the value derived from RT_DATSpt_shift (by default, 60%), as long as pressure control is not used and the manual setting is lower than that derived from the temperature control function.

4. The fixed-value temperature control function consists of adjusting the discharge air temperature connected at the U1 input of the AAC20 controller (Discharge Air Temperature) based on the set TempSpt temperature (by default, 22°C), and based on the control loop the control level for the heater or cooler and exchanger is calculated.
5. The cascade control function with comfort zone consists of adjusting the discharge air temperature connected at the U1 input of the AAC20 (Discharge Air Temperature) to achieve a set discharge air temperature separate for the heating and cooling functions, taking into account the RT_ComfortZone comfort zone between them (the optimal zone in which heating and cooling are not adjusted – by default, 2°C). The setpoint of discharge temperature is the output from the return temperature control system connected to the U2 input of the AAC20 controller (Return Air Temperature) to achieve the set temperature defined by the TempSpt variable (default 22°C). In addition, the discharge air temperature control system can affect the speed of the fans by allowing them to run above the value derived from RT_DATSpt_shift (by default, 60%), unless pressure control is used or the manual speed setting is lower than that derived from the discharge air temperature control function.
6. For the cascade function with comfort zone, the heat or cooling recovery system works in the comfort zone by controlling the exchanger accordingly. When using the economizer function, the control signal can be reversed.
7. The setpoint of discharge temperature is calculated from DAT_LowSetpoint (by default, 14°C) to DAT_HighSetpoint (by default, 26°C).
8. If the discharge air temperature falls below the low limit, the cooler is gradually closed, the heat exchanger begins to work on heat recovery, and the heater begins to open.
9. If the discharge air temperature rises above the high limit, the heater is gradually closed, the heat exchanger begins to work on the recovery of cooling, and the cooler begins to open.
10. The TempSpt set temperature (by default, 22°C) can take into account the winter compensation specified by the WC_DischSptRaise parameter (by default, 4K) or the summer compensation specified by the SC_DischSptRaise parameter (by default, 4K).
11. In the case of a night temperature drop, the RT_ComfortZone comfort zone is expanded four times.
12. In the case of active humidification function, the fan speed can gradually increase with the humidifier control signal, as long as pressure control is not used and the manual setting is lower than the humidification control function.
13. In the case of active dehumidification function using an economizer in mode 2, the fan speed is gradually increased (with attention to the above), and the cooler is opened in turn.
14. When the absolute humidity outside is higher than that of the return, the sequence changes, causing the cooler to open first, and then increase the speed of the fan (with a note as above).
15. In summer, if the outside temperature rises above the OAT_HeaterLimit (by default, 20°C), heater control is blocked, and in winter, if the outside temperature falls below the OAT_CoolerLimit (by default, 14°C), cooler control is blocked.

16. When the antifreeze protection is triggered, all control signals are reset except for the signal for the heater which is set to the level specified in HTV_FrostProt_ValveUp (by default, 100%). When the risk of freezing ceases, all signals return to normal operation.
17. The heater valve is opened or closed by the valve actuator according to the control signal coming from the temperature control system according to the configured TempCtrlMode.

Reheater

1. When HeaterMode (mode 2) is selected as operation mode for both primary and secondary heaters, then when the humidification function is active, only the primary heater works, and when the dehumidification function is in operation, only the secondary heater is used for temperature control.
2. If no humidity control is used (or no active humidification or dehumidification function), both heaters work simultaneously in the temperature control function, but can be configured as needed for gradual operation (the primary heater is the first stage, and the secondary is the second).
3. If the secondary heater pump is activated in HPU_Enable (active by default - true) and connected to the A4 output of the module 4U4A-H or MIX18 (ReHeating Pump Start Command), it is switched on with the delay HPU_OnDelay (by default, 5 s) when the secondary heater valve connected to the A2 output in the module 4U4A-H or MIX18 (ReHeating Valve) opens to 3% or more, and is switched off with the delay specified in HPU_OffDelay (by default, 300 s) when the valve is opened 1% or less.
4. In winter, when the outdoor temperature drops below the OAT_FrostProtection value (by default, 6°C) at the start of the AHU system, the secondary heater valve opens according to the HTV_FrostProt_ValveUp parameter (by default, 100%) and drops at the rate specified by HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current system control.
5. In winter, the secondary heater pump is permanently activated if the outdoor temperature falls below the OAT_FrostProtection limit (by default, 6°C) with a central hysteresis of 1K.
6. When using the secondary heater pump failure signal which is connected to the U4 input of the module 4U4A-H or the I2 input of the module MIX18 (ReHeating Pump Fault) and when the value in HPU_StatusAlarmDelay (by default, 1 s) is set to default, an alarm is generated on the O2 output of the module MIX18 (Heat Pumps Failure Alarm) and the pump control output is disabled. The alarm is automatically reset if the input signal is deactivated and the pump resumes operation.
7. An additional feature to ensure a proper and long-lasting operation of the devices operating the secondary heater is exercising the pump and valve. First, the pump is exercised, then the valve, which, by default, takes place every Sunday at 1am in case they are not in use. The exercise consists of turning on the pump for the time specified in HPU_Pmp_Vlv_Exercise (120 s by default) and then opening the valve to 100% for the same time as above.

Cooler

1. When cooling is needed, the cooler valve connected to the A2 output (Cooling Valve) opens based on a stronger signal coming from the temperature control system or dehumidification function.

2. The control of the cooler valve is blocked below the OAT_CoolerLowLimit temperature (by default, 14°C) with a central hysteresis of 1K.
3. It is possible to block the control of the cooler valve in the humidification function with the CCV_CoolOnHumDisable parameter (active by default – true).
4. During the AHU startup and each time the valve is opened from zero, the control signal gradually increases at the rate specified in CCV_VlvRamp (by default, 5%/min).
5. To protect against too low air temperature behind the cooler, it is possible to use a temperature sensor connected to the U3 input on the MIX18 module (Cooling Limit Air Temperature) causing the cooler valve to gradually close when the temperature drops to the LIM_Setpoint value (by default, 14°C).
6. An additional feature to ensure a proper and long-lasting operation of the cooler is exercising the valve. It is carried out by default every Sunday at 1am in case it is not being used. Exercise consists of opening the valve to 100% for the time specified in CCV_Vlv_Exercise (120 s by default).

Exchanger

1. In order to increase energy efficiency, the AHU system is additionally equipped with an exchanger to recover thermal energy (heat or cold) from either return or outside air in order to use this energy to heat or cool the incoming outside air.
2. One of five types of exchanger can be selected in EnergyRecovMode. Type 1 indicates a wheel heat exchanger.
3. When the AHU system is started, the exchanger control enable starts with the delay specified in ERP_OnDelay (by default, 5 s).
4. The exchanger is controlled at the A5 output of the AAC20 (Wheel Exchanger Control) primarily from the temperature control system, but its control is also affected by the economizer function and humidity control.
5. To protect the exchanger from frosting, a signal connected to the U7 input of the AAC20 (Wheel Exchanger Pressure Switch) is used to disable the exchanger control and the control signal is set to zero.
6. In addition, in the case of using a temperature sensor connected at the U4 input of the MIX18 module (Exhaust Air Temperature) located on the outlet behind the exchanger, the exchanger can be smoothly controlled by decreasing its control when the outside temperature decreases, which serves to protect against frosting.
7. If the exchanger control signal is equal to or greater than 3%, the exchanger will be given permission to operate the exchanger by switching on the O4 output in the AAC20 (Wheel Exchanger Start Command).
8. If the exchanger control signal is equal to or less than 1% after ERP_OffDelay (by default, 300 s), the exchanger will be disabled.
9. Permission to operate can be switched on permanently during normal operation of the AHU system, if the outside temperature falls below OAT_FrostProtection (by default, 6°C) or the ERP_WheelRelease parameter is activated (deactivated by default - false).
10. When using the exchanger failure signal which is connected to the I4 input on the MIX18 module (Wheel Exchanger Fault) and when the value in ERP_StatusAlarmDelay (default 1s) is set to default, an alarm is generated on the O3 output of the MIX18 module (Wheel Exchanger Failure Alarm), the exchanger is controlled to zero, and it gets disabled. The alarm is automatically reset if the input signal is deactivated and the exchanger resumes operation.

Economizer

1. In addition, an economizer function is used to support energy efficiency, the mode of which can be set in the EconomizerMode.
2. The Economizer in operation mode 1 compares only the outdoor and return temperatures to determine the optimal signal for energy recovery by the exchanger.
3. In mode 2, the economizer determines the energy recovery function based on measurements of outdoor and return temperatures and humidity, deciding in the summer using the calculated enthalpy and absolute humidity which air flow to use for cooling (return or fresh).
4. Calculations based on absolute humidity apply only when using the dehumidification function.
5. Both functions, enthalpy and absolute humidity, are triggered when the appropriate conditions are met taking into account the central hysteresis of EnthalpyDiff (by default, 5kJ/kg) and AbsHumDiff (by default, 1g/kg) respectively, with a delay specified by SwitchoverDel (by default, 300s).

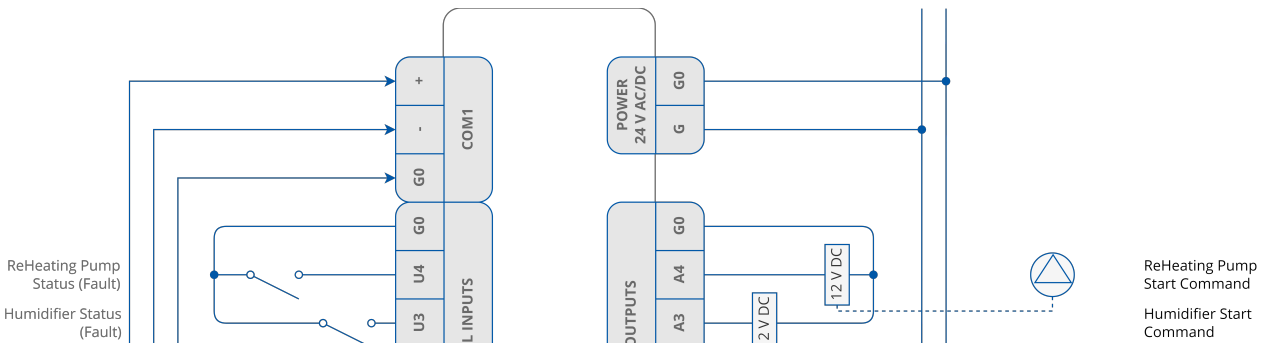
Humidifier

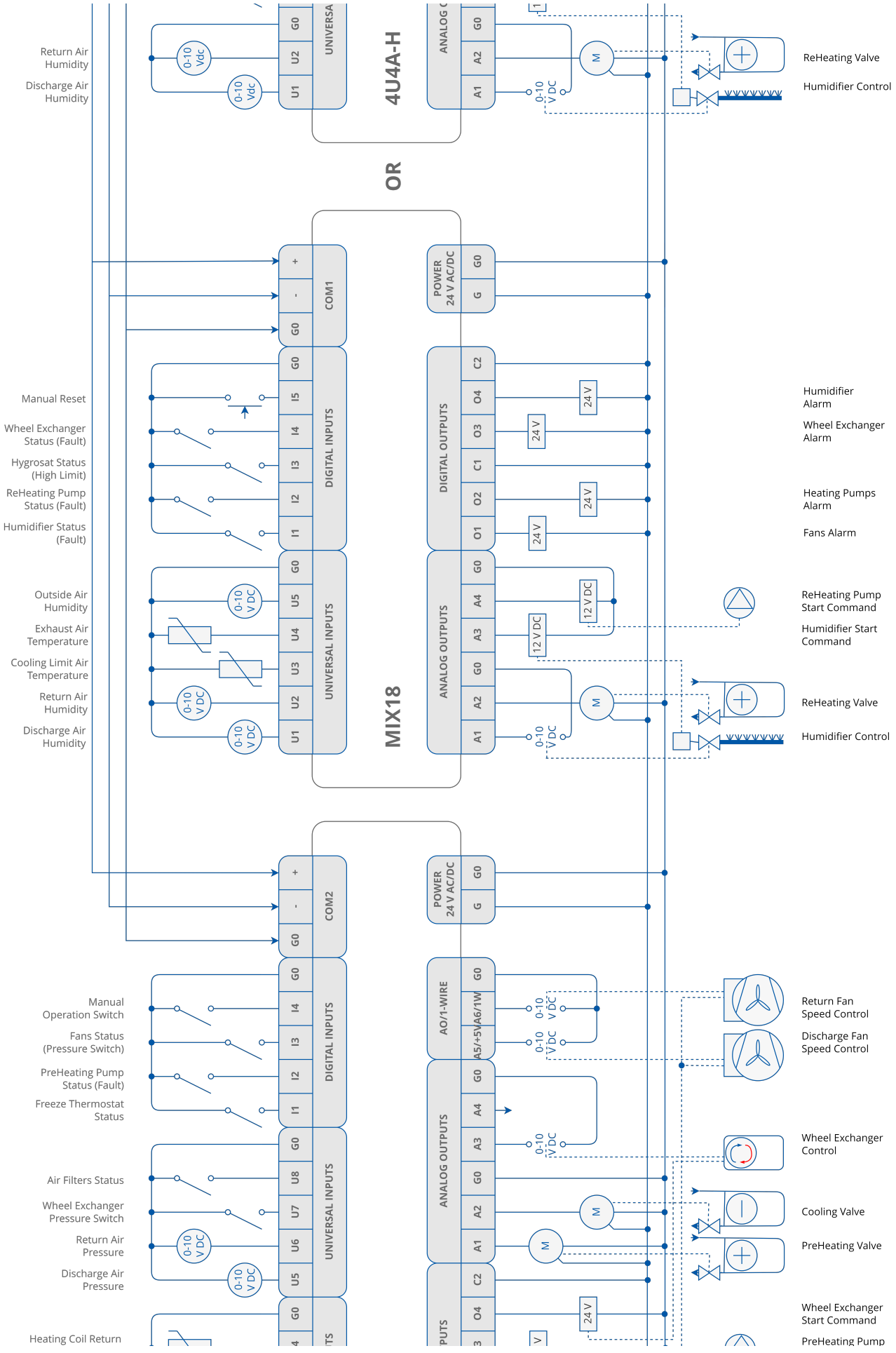
1. The AHU is also equipped with a humidification and dehumidification function. The humidification function is started with a delay of HUM_FanOnDelay (by default, 300 s) after confirming the operation of the fans connected to the I3 input in the AAC20 (Fans Status/Pressure Switch).
2. In case of lack of confirmation that the fans connected to the I3 input of the AAC20 (Fans Status/Pressure Switch) is operating, the humidification function is turned off immediately.
3. The humidification function is active when the outdoor temperature is lower than the OAT_HighHum parameter (by default, 14°C), and the dehumidification function is active when the outdoor temperature is higher than the OAT_LowDeh parameter (by default, 15°C).
4. To implement humidity control, a discharge air sensor connected to the U1 input of the 4U4A-H or MIX18 (Discharge Air Humidity) module and an return air sensor connected to the U2 input of the 4U4A-H or MIX 18 (Return Air Humidity) module are required, depending on the selected humidity control function.
5. The application allows to configure the HumCtrlMode humidity control function in 4 modes described below.
6. The function of return relative humidity control with comfort zone (optimal zone in which humidification and dehumidification control does not take place) is to regulate humidity so as to achieve HumSpt as the setpoint for return (by default, 55%) taking into account the comfort zone HUMDEH_ComfZone (by default, 4%) using humidification or dehumidification function. The comfort zone is quadrupled in the case of night temperature drop.
7. The function of controlling the return relative humidity without comfort zone is to adjust the humidity to achieve the HumSpt as the setpoint for the return (by default, 55%) using the humidification or dehumidification function.
8. The function of the discharge absolute humidity control is to adjust the humidity so as to achieve the discharge setpoint determined by the value from the return humidity sensor. The discharge humidity setpoint is calculated by the control loop, which is then used to regulate the discharge humidity using humidification or dehumidification

functions. An absolute (not relative) humidity sensor connected on the discharge air is required to perform this function.

9. The function of the fixed-value absolute humidity discharge control is to adjust the humidity so as to achieve the HumSpt as the discharge setpoint (by default, 55%) using the humidification or dehumidification function. An absolute (not relative) humidity sensor connected on the discharge air is required to perform this function.
10. The humidity control function has two independent control loops, one for humidification control directly controlling the humidifier connected to the A1 output of the AAC20 controller (Humidifier Control Signal), and the other for dehumidification control affecting the control of the cooler connected to the A2 output of the AAC20 controller (Cooling Valve). The maintenance of the previously reduced temperature to the set level according to the temperature control is done by controlling the secondary heater connected to the A2 output of the 4U4A-H or MIX18 module (ReHeating Valve).
11. Both humidification and dehumidification control functions ramp up gradually at the speed of HUM_RampUp (by default, 10%/min) and DEH_RampUp (by default, 10%/min), respectively.
12. The HumSpt set humidity (by default, 55%) can take into account either winter compensation determined by a linear function in relation to the outside temperature from RAH_MinHumSpt (by default, 30%Rh) to HumSpt (by default, 55%) or summer compensation determined by a linear function in relation to the outside temperature from HumSpt (by default, 55%) to RAH_MaxHumSpt (by default, 60%Rh).
13. Depending on the type of humidifier selected in HumidifierMode, the A3 output control in the 4U4A-H or MIX18 module (Humidifier Start Command) is activated as required: as a water humidifier pump (mode 1) or as switched on permanently (if there is no failure) during AHU operation as a steam humidifier enabler (mode 2).
14. In case of a humidifier failure activated at the U3 input of the 4U4A-H module or at the I1 input of the MIX18 module (Humidifier Fault), the humidifier control is turned off, the water humidifier pump/steam humidifier is shut down, and an alarm is generated at the O4 output of the MIX18 module (Humidifier Failure Alarm).
15. In addition to the hygrostat connected to the I3 input of the MIX 18 module (Hygrostat), which, when activated, turns off the humidification function (turns off the humidifier and pump / permit control), there is also a function to protect the occurrence of too much discharge humidity (to prevent the ducts from getting wet). If the discharge air humidity begins to increase towards the DAH_MaxSpt value (by default, 90%), then the humidifier control gradually decreases to zero.
16. Deactivation of the humidistat or humidifier failure automatically resets the alarm and returns to normal control mode.

8.5.3 Electrical Connections




4U4A-H
OR
MIX18
Return Air Humidity
Discharge Air Humidity
Manual Reset
Wheel Exchanger Status (Fault)
Hygrosat Status (High Limit)
ReHeating Pump Status (Fault)
Humidifier Status (Fault)
Outside Air Humidity
Exhaust Air Temperature
Cooling Limit Air Temperature
Return Air Humidity
Discharge Air Humidity
Manual Operation Switch
Fans Status (Pressure Switch)
PreHeating Pump Status (Fault)
Freeze Thermostat Status
Air Filters Status
Wheel Exchanger Pressure Switch
Return Air Pressure
Discharge Air Pressure
Heating Coil Return
ReHeating Valve
Humidifier Control
Humidifier Alarm
Wheel Exchanger Alarm
Heating Pumps Alarm
Fans Alarm
ReHeating Pump Start Command
Humidifier Start Command
ReHeating Valve
Humidifier Control
Return Fan Speed Control
Discharge Fan Speed Control
Wheel Exchanger Control
Cooling Valve
PreHeating Valve
Wheel Exchanger Start Command
PreHeating Pump
COM1
COM2
DIGITAL INPUTS
UNIVERSAL INPUTS
DIGITAL OUTPUTS
ANALOG OUTPUTS
AO/1-WIRE
POWER 24 V AC/DC

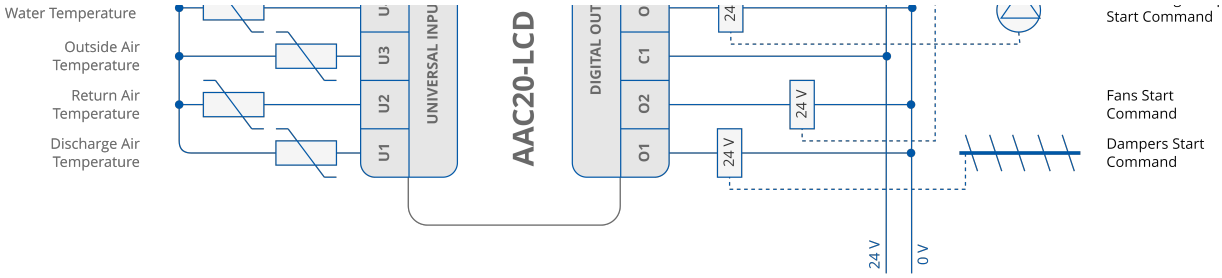


Figure 90. Electrical connections for supply and exhaust air handling unit with wheel exchanger, water heaters and water cooler, with humidification and dehumidification function

8.6 Example 6

8.6.1 Supply and Exhaust Air Handling Unit with Cross-flow Exchanger, Water Heaters and Water Cooler, with Humidification and Dehumidification Function

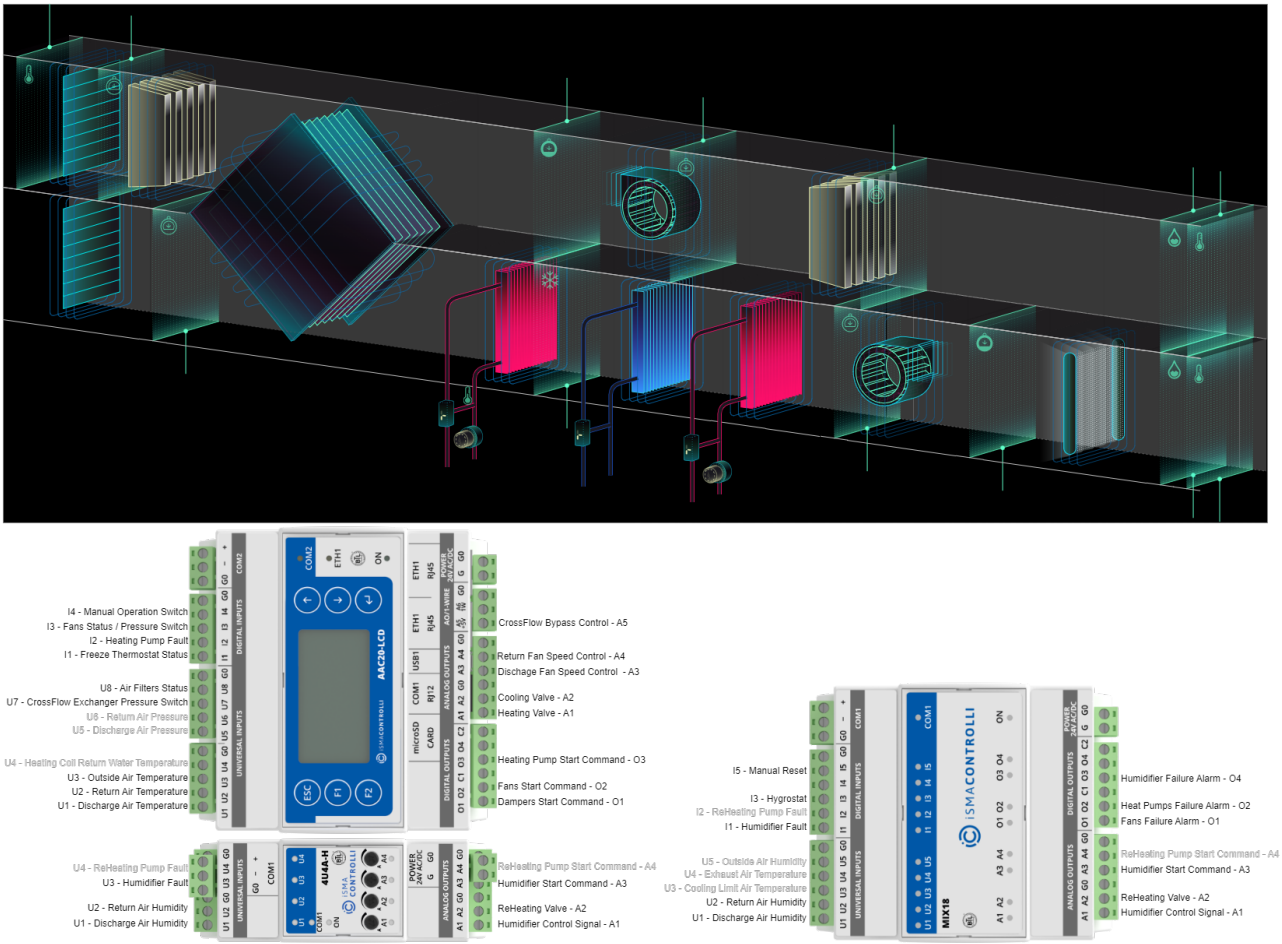


Figure 91. Inputs and outputs configured for supply and exhaust air handling unit with cross-flow exchanger, water heaters and water cooler, with humidification and dehumidification function

The air handling unit consists of:

- 2-position inlet and outlet damper;
- air supply and exhaust filter;
- cross-flow exchanger;
- water preheater with a valve and a preheater pump;

- water cooler with a valve;
- water reheater with a valve and, optionally, a reheater pump;
- supply and exhaust fans controlled by an inverter;
- humidifier.

The AAC20 controller is sufficient if the dehumidification and humidification functions are not used. To enable humidity control, it is required to add an additional extension I/O module, iSMA-B-4U4A or -MIX18, to the AAC20 controller (depending on the demand and required sensors/signals).

The required sensors/signals are:

- discharge air temperature sensor;
- return air temperature sensor;
- outside air temperature sensor;
- cross-flow exchanger pressure switch or cross-flow exchanger exhaust air temperature (for MIX18 only);
- discharge air humidity sensor (for humidification and dehumidification functions);
- return air humidity sensor (for humidification and dehumidification functions);
- anti-freeze thermostat;
- humidifier failure status (if is required and is installed, can be used in conjunction with a hygrostat for the MINI module);
- hygrostat (if is required and is installed);
- fans operating status (pressure switch, signal from the inverter) – connected in series;
- manual switch control (permission to operate the ventilation system).

Some of the useful sensors/signals,optional but not required:

- preheat pump failure status;
- reheat pump failure status (if reheat pump is installed);
- filters dirty status (for monitoring only) – connected in parallel;
- manual reset (for MIX18 only, in case of manual fault reset).

In addition, the system can be equipped with extra sensors/signals, such as:

- outside air humidity;
- heater return water temperature;
- cooler limit air temperature;
- discharge air pressure sensor (only when there is a need to maintain constant pressure on the supply duct);
- return air pressure sensor (only when there is a need to maintain constant pressure on the exhausts duct).

The application allows for:

- controlling the opening/closing of the 2-position inlet and outlet dampers;
- the fans to start and controlling their speed (constant or pressure dependent);
- controlling the modulating (analog 0-10 V DC) bypass of cross-flow exchanger;
- controlling the modulating (analog 0-10 V DC) preheater valve actuator and the preheater pump;
- controlling the modulating (analog 0-10 V DC) reheater valve actuator (used for the dehumidification function) and, optionally, reheater pump;
- controlling the modulating (analog 0-10 V DC) cooler valve actuator;
- the humidifier to start and controlling its humidification performance.

If the MIX18 module is used, it is also possible to signal alarm states for the fans (common alarm), heaters pump (common alarm), and humidifier.

AHU configuration example:

- heater mode – **PreHeater & ReHeater [2]**
- energy recovery mode – **Cross Flow [2]**
- cooler mode – **Cooler [1]**
- humidifier mode – **Water Humidifier or Steam Humidifier [1 or 2]** (depending on the need)
- economizer mode – **None, Eco Return Temp or Eco Enthalpy [0, 1 or 2]** (depending on the need)
- temperature control mode – **Cascade Temp, Constant Disch Temp or Comfort Zone Temp [1, 2 or 3]** (depending on the need)
- humidity control mode – **Comfort Hum, Return Hum, Disch Abs Hum or Constant Disch Abs Hum [1, 2, 3 or 4]** (depending on the need)

8.6.2 Application Algorithm Description

Start-up

1. The first step after configuring the application for a particular type of the AHU is to make sure that the time schedule is correctly configured, which allows the AHU to run in a normal mode (Plant Mode as Occupied Period [4]) or in a night mode (with reduced efficiency - Plant Mode as Night Cycle [2]). If not, the time schedule must first be set correctly to allow a proper AHU operation.
2. The signal that allows the AHU to start is the signal connected to the I4 input of the AAC20 (Operating Switch). Activating this signal (physical short circuit at the input) and correctly setting the time schedule allows the AHU to start, while deactivating the signal automatically stops the AHU.

Preheater

1. The next step before starting the AHU is for the controller to verify that the heater has no active alarm conditions associated with the antifreeze protection procedure.
2. The antifreeze protection of the heater is used in the winter period (when the outside temperature is lower than the limit set by OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K).
3. The basic element is the antifreeze thermostat whose physical setting should be in accordance with or slightly lower than the above limit (e.g., by 1°C). The antifreeze thermostat is connected to the I1 input on the AAC20 controller (Freeze Thermostat Status).
4. Activation of the antifreeze thermostat (physical short circuit at the input) triggers the antifreeze protection procedure consisting of stopping the AHU (turning off the fans and closing the dampers), opening the heater valve at output A1 of the AAC20 (Heating Valve) to the level specified in HTV_FrostProt_ValveUp (by default, 100%), and switching on the heater pump at output O3 (Heating Pump Start Command) if configured for use by HPU_Enable (by default, active - true).
5. An additional element of antifreeze protection is the use of a return water temperature sensor connected to the U4 input in the AAC20 (Heating Coil Return Water Temperature). If the antifreeze thermostat is triggered, the setpoint for the

return water temperature is raised additionally by the level specified in FEZ_RWT_SptUp (by default, 15K).

6. When the temperature of the heater rises and the antifreeze thermostat returns to the normal state, In such case, if there is a sensor for the water temperature at the return from the heater, its setpoint will begin to fall at the rate of FEZ_SetupRamp (default 1K/min) to the normal setpoint (calculated on the basis of the outside temperature); if there is no sensor, the valve closes at the rate of HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current system control.
7. The heater return water temperature sensor also serves as a high limit for the water temperature in the heater by closing the valve if the temperature specified in RWT_MaxSetpoint is too high (85°C by default).
8. If the pump is activated in HPU_Enable (active by default - true) and connected to the O3 output in the AAC20 (Heating Pump Start Command), it is switched on with the delay HPU_OnDelay (by default, 5 s) when the heater valve connected to the A1 output in the AAC20 (Heating Valve) opens to 3% or more, and switched off with the delay specified in HPU_OffDelay (by default, 300 s) when the valve is open 1% or less.
9. In winter, the pump is permanently activated if the outside temperature falls below the OAT_FrostProtection limit (by default, 6°C) with a central hysteresis of 1K and if the antifreeze thermostat is activated.
10. When using the pump failure signal, which is connected to the I2 input on the AAC20 (Heating Pump Fault), and when the value in HPU_StatusAlarmDelay (by default, 1 s) is set to default, then in the winter period the AHU can be turned off if:
    a. DME_EmergencyStop (deactivated by default - false) is active (set to true),
    b. an alarm is generated on the O2 output of the MIX18 module (Heat Pumps Failure Alarm), and
    c. the pump control output is turned off.
    The alarm is automatically reset if the signal at the input is deactivated and the pump and AHU system resume operation (if stopped).
11. An additional feature to ensure a proper and long-lasting operation of the devices operating the heater is exercising the pump and valve. First, the pump is exercised, then the valve, which, by default, takes place every Sunday at 1am in case they are not in use. The exercise consists of turning on the pump for the time specified in HPU_Pmp_Vlv_Exercise (120 s by default) and then opening the valve to 100% for the same time as above.

Dampers

1. In winter, when the outside temperature is lower than the limit specified by OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K and the return water temperature sensor is used, then, it must reach the setpoint (calculated from the outside temperature) to allow the dampers to open after the time specified in DME_OnDelay (by default, 300 s).
2. If the return water temperature sensor from the heater is not used, the dampers are opened only after the time specified in DME_OnDelay (by default, 300 s), during which the valve is opened according to the HTV_FrostProt_ValveUp parameter (by default, 100%) and drops at the rate specified by HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current system control.
3. When the outside temperature is above the limit specified in OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K (summer period), the dampers are opened

without the delay specified in DME_OnDelay (by default, 300 s) and the heater return water temperature is not controlled at that time.
4. The dampers connected to the O1 output in the AAC20 (Dampers Start Command) open after the time specified in DME_OnDelay (by default, 300 s) only after the permission from the normally operating heater, and then the signal from the dampers are transmitted as a start permission for the fans with a delay of MAD_RunTime (by default, 150 s).

Fans

1. If pressure sensors is connected at the U5 and U6 input in the AAC20 (Discharge Air Pressure, Return Air Pressure), each fan in is controlled smoothly connected at the A3 or A4 output in the AAC20 (Discharge Fan Speed Control, Return Fan Speed Control) in the range from FSC_MinSignal (by default, 30%) to FCS_MaxSignal (by default, 100%) so as to maintain the set pressures, or is controlled from the control signal resulting from humidity or manually with a set speed in the above ranges in the absence of connected pressure sensors (the higher control value is selected).
2. Each fan has its preset DischPressSpt pressure (500 Pa by default) and ReturnPressSpt pressure (500 Pa by default), which it is supposed to maintain by adjusting its speed accordingly.
3. Fans connected to the O2 output in the AAC20 (Fans Start Command) start with the delay specified in FSC_OffOnDelay (by default, 5 s) after receiving a permission from the dampers.
4. After receiving the startup permission, the fan speed control signal slowly ramps up at the rate of FSC_Ramp (by default, 1%/min) to the desired value resulting from the corresponding control as indicated above. The rate of rise or fall of the control signal is determined by the same speed.
5. The pressure setpoint behaves similarly, which during the AHU startup ramps up from zero to the desired setpoint at the speed of DSP_PressSptRamp (by default, 50 Pa/min). If it is changed during a normal operation, it will correspondingly start falling or rising at the same speed specified in DSP_PresSptRamp (by default, 50 Pa/min).
6. For a night mode, the set pressure is reduced by multiplying it by the DSP_NightReduce factor (by default, 50%).
7. To protect the fans operation, a fans confirmation signal is connected to the I3 input in the AAC20 (Fans Status/Pressure Switch), which if not activated by the time FDP_BeltAlarmDelay (default 120s), then, an alarm is generated on the O1 output of MIX18 (Fans Failure Alarm) and this causes the AHU to stop. This function can be disabled by setting the zero value in FDP_BeltAlarmDelay (by default, 120 s).
8. In the automatic reset mode specified in FSC_ManualReset (by default, false), after an alarm from the fan, the alarm will be reset and the AHU will resume operation, while after three unsuccessful attempts to start, the system stops and in the automatic mode it can be reset by removing and reactivating the I4 input in AAC20 (Operating Switch). While if the manual reset mode specified in FSC_ManualReset (deactivated - false by default) is set to true, after an alarm from the fan the AHU will be stopped and the controller will wait for a reset signal activated by the input connected to the I5 input in MIX18 (Reset) and only then will it attempt to restart the AHU.

Control

1. In winter, during the AHU startup, the temperature control system temporarily raises the setpoint for the discharge temperature by an additional value specified in DAT_SptRamp (by default, 1K) which drops in time specified in DAT_SptDecTime (by default, 600 s).
2. The application allows to configure the TempCtrlMode temperature control function in 3 modes described below.
3. The cascade control function consists of regulating the discharge temperature connected to the U1 input of the AAC20 (Discharge Air Temperature), whose setpoint is determined by the control loop of the return temperature connected to the U2 input of the AAC20 (Return Air Temperature) and the setpoint of the exhaust temperature TempSpt (by default, 22°C) in the heating or cooling function (with the exchanger as the first stage in both cases or without), as well as the fan speed allowing the fans to run above the value derived from RT_DATSpt_shift (by default, 60%), as long as pressure control is not used and the manual setting is lower than that derived from the temperature control function.
4. The fixed-value temperature control function consists of adjusting the supply air temperature connected at the U1 input of the AAC20 controller (Discharge Air Temperature) based on the set TempSpt temperature (by default, 22°C), and based on the control loop the control level for the heater or cooler and exchanger is calculated.
5. The cascade control function with comfort zone consists of adjusting the discharge air temperature connected at the U1 input of the AAC20 (Discharge Air Temperature) to achieve a set discharge air temperature separate for the heating and cooling functions, taking into account the RT_ComfortZone comfort zone between them (the optimal zone in which heating and cooling are not adjusted – by default, 2°C). The setpoint of discharge temperature is the output from the return temperature control system connected to the U2 input of the AAC20 controller (Return Air Temperature) to achieve the set temperature defined by the TempSpt variable (default 22°C). In addition, the discharge air temperature control system can affect the speed of the fans by allowing them to run above the value derived from RT_DATSpt_shift (by default, 60%), unless pressure control is used or the manual speed setting is lower than that derived from the discharge air temperature control function.
6. For the cascade function with comfort zone, the heat or cooling recovery system works in the comfort zone by controlling the exchanger accordingly. When using the economizer function, the control signal can be reversed.
7. The setpoint of discharge temperature is calculated from DAT_LowSetpoint (by default, 14°C) to DAT_HighSetpoint (by default, 26°C).
8. If the discharge air temperature falls below the low limit, the cooler is gradually closed, the heat exchanger begins to work on heat recovery, and the heater begins to open.
9. If the discharge air temperature rises above the high limit, the heater is gradually closed, the heat exchanger begins to work on the recovery of cooling, and the cooler begins to open.
10. The TempSpt set temperature (by default, 22°C) can take into account the winter compensation specified by the WC_DischSptRaise parameter (by default, 4K) or the summer compensation specified by the SC_DischSptRaise parameter (by default, 4K).
11. In the case of a night temperature drop, the RT_ComfortZone comfort zone is expanded four times.

12. In the case of active humidification function, the fan speed can gradually increase with the humidifier control signal, as long as pressure control is not used and the manual setting is lower than the humidification control function.
13. In the case of active dehumidification function using an economizer in mode 2, the fan speed is gradually increased (with attention to the above), and the cooler is opened in turn.
14. When the absolute humidity outside is higher than that of the exhaust, the sequence changes, causing the cooler to open first, and then increase the speed of the fan (with a note as above).
15. In summer, if the outside temperature rises above the OAT_HeaterLimit (by default, 20°C), heater control is blocked, and in winter, if the outside temperature falls below the OAT_CoolerLimit (by default, 14°C), cooler control is blocked.
16. When the antifreeze protection is triggered, all control signals are reset except for the signal for the heater which is set to the level specified in HTV_FrostProt_ValveUp (by default, 100%). When the risk of freezing ceases, all signals return to normal operation.
17. The heater valve is opened or closed by the valve actuator according to the control signal coming from the temperature control system according to the configured TempCtrlMode.

Reheater

1. When HeaterMode (mode 2) is selected as operation mode for both primary and secondary heaters, then when the humidification function is active, only the primary heater works, and when the dehumidification function is in operation, only the secondary heater is used for temperature control.
2. If no humidity control is used (or no active humidification or dehumidification function), both heaters work simultaneously in the temperature control function, but can be configured as needed for gradual operation (the primary heater is the first stage, and the secondary is the second).
3. If the secondary heater pump is activated in HPU_Enable (active by default - true) and connected to the A4 output of the module 4U4A-H or MIX18 (ReHeating Pump Start Command), it is switched on with the delay HPU_OnDelay (by default, 5 s) when the secondary heater valve connected to the A2 output in the module 4U4A-H or MIX18 (ReHeating Valve) opens to 3% or more, and is switched off with the delay specified in HPU_OffDelay (by default, 300 s) when the valve is opened 1% or less.
4. In winter, when the outdoor temperature drops below the OAT_FrostProtection value (by default, 6°C) at the start of the AHU system, the secondary heater valve opens according to the HTV_FrostProt_ValveUp parameter (by default, 100%) and drops at the rate specified by HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current system control.
5. In winter, the secondary heater pump is permanently activated if the outdoor temperature falls below the OAT_FrostProtection limit (by default, 6°C) with a central hysteresis of 1K.
6. When using the secondary heater pump failure signal which is connected to the U4 input of the module 4U4A-H or the I2 input of the module MIX18 (ReHeating Pump Fault) and when the value in HPU_StatusAlarmDelay (by default, 1 s) is set to default, an alarm is generated on the O2 output of the module MIX18 (Heat Pumps Failure Alarm) and the pump control output is disabled. The alarm is automatically reset if the input signal is deactivated and the pump resumes operation.

7. An additional feature to ensure a proper and long-lasting operation of the devices operating the secondary heater is exercising of the pump and valve. First, the pump is exercised, then the valve, which, by default, takes place every Sunday at 1am in case they are not in use. The exercise consists of turning on the pump for the time specified in HPU_Pmp_Vlv_Exercise (120 s by default) and then opening the valve to 100% for the same time as above.

Cooler

1. When cooling is needed, the cooler valve connected to the A2 output (Cooling Valve) opens based on a stronger signal coming from the temperature control system or dehumidification function.
2. The control of the cooler valve is blocked below the OAT_CoolerLowLimit temperature (by default, 14°C) with a central hysteresis of 1K.
3. It is possible to block the control of the cooler valve in the humidification function with the CCV_CoolOnHumDisable parameter (active by default – true).
4. During the AHU startup and each time the valve is opened from zero, the control signal gradually increases at the rate specified in CCV_VlvRamp (by default, 5%/min).
5. To protect against too low air temperature behind the cooler, it is possible to use a temperature sensor connected to the U3 input on the MIX18 module (Cooling Limit Air Temperature) causing the cooler valve to gradually close when the temperature drops to the LIM_Setpoint value (by default, 14°C).
6. An additional feature to ensure a proper and long-lasting operation of the cooler is exercising the valve. It is carried out by default every Sunday at 1am in case it is not being used. Exercise consists of opening the valve to 100% for the time specified in CCV_Vlv_Exercise (120 s by default).

Exchanger

1. In order to increase energy efficiency, the AHU system is additionally equipped with an exchanger to recover thermal energy (heat or cold) from either return or outside air in order to use this energy to heat or cool the incoming outside air.
2. One of five types of exchanger can be selected in EnergyRecovMode. Type 2 indicates a cross-flow heat exchanger.
3. The exchanger is controlled at the A5 output of the AAC20 (CrossFlow Bypass Control) primarily from the temperature control system, but its control is also affected by the economizer function, humidity control.
4. To protect the exchanger from frosting, a signal connected to the U7 input of the AAC20 (CrossFlow Exchanger Pressure Switch) is used to disable the exchanger control and the control signal is set to zero.
5. In addition, in the case of using a temperature sensor connected at the U4 input of the MIX18 module (Exhaust Air Temperature) located on the outlet behind the exchanger, the exchanger can be smoothly controlled by decreasing its control when the outside temperature decreases, which serves to protect against frosting.

Economizer

1. In addition, an economizer function is used to support energy efficiency, the mode of which can be set in the EconomizerMode.

2. The Economizer in operation mode 1 compares only the outdoor and return temperatures to determine the optimal signal for energy recovery by the exchanger.
3. In mode 2, the economizer determines the energy recovery function based on measurements of outdoor and return temperatures and humidity, deciding in the summer using the calculated enthalpy and absolute humidity which air flow to use for cooling (exhaust or fresh).
4. Calculations based on absolute humidity apply only when using the dehumidification function.
5. Both functions, enthalpy and absolute humidity, are triggered when the appropriate conditions are met taking into account the central hysteresis of EnthalpyDiff (by default, 5kJ/kg) and AbsHumDiff (by default, 1g/kg) respectively, with a delay specified by SwitchoverDel (by default, 300s).

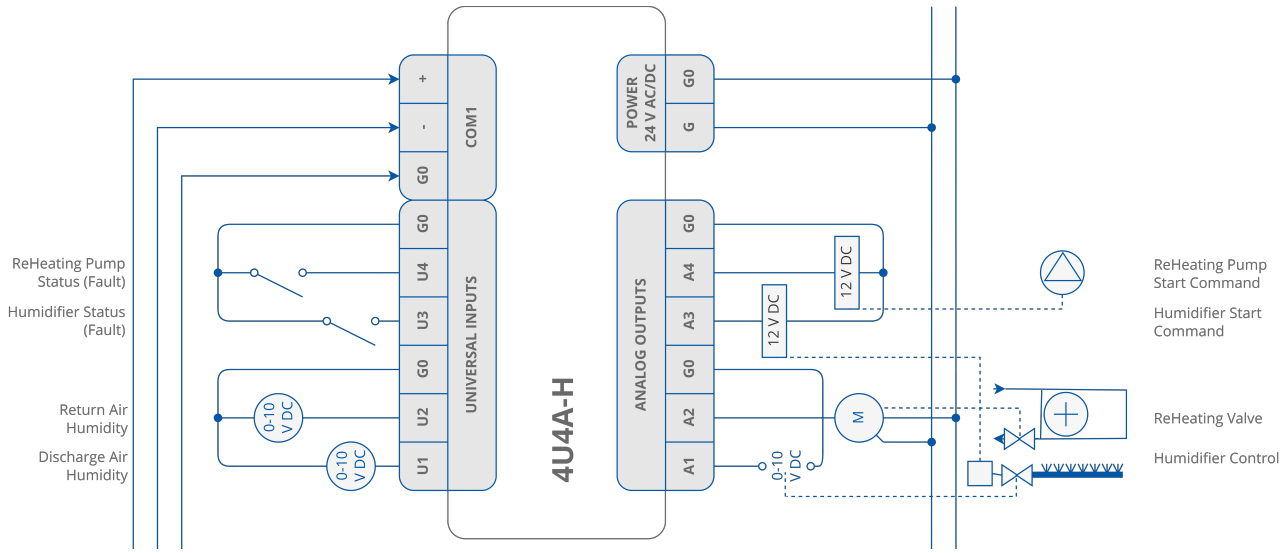
Humidifier

1. The AHU is also equipped with a humidification and dehumidification function. The humidification function is started with a delay of HUM_FanOnDelay (by default, 300 s) after confirming the operation of the fans connected to the I3 input in the AAC20 (Fans Status/Pressure Switch).
2. In case of lack of confirmation that the fans connected to the I3 input of the AAC20 (Fans Status/Pressure Switch) is operating, the humidification function is turned off immediately.
3. The humidification function is active when the outdoor temperature is lower than the OAT_HighHum parameter (by default, 14°C), and the dehumidification function is active when the outdoor temperature is higher than the OAT_LowDeh parameter (by default, 15°C).
4. To implement humidity control, a discharge air sensor connected to the U1 input of the 4U4A-H or MIX18 (Discharge Air Humidity) module and an return air sensor connected to the U2 input of the 4U4A-H or MIX 18 (Return Air Humidity) module are required, depending on the selected humidity control function.
5. The application allows to configure the HumCtrlMode humidity control function in 4 modes described below.
6. The function of return relative humidity control with comfort zone (optimal zone in which humidification and dehumidification control does not take place) is to regulate humidity so as to achieve HumSpt as the setpoint for return (by default, 55%) taking into account the comfort zone HUMDEH_ComfZone (by default, 4%) using humidification or dehumidification function. The comfort zone is quadrupled in the case of night temperature drop.
7. The function of controlling the return relative humidity without comfort zone is to adjust the humidity to achieve the HumSpt as the setpoint for the return (by default, 55%) using the humidification or dehumidification function.
8. The function of the discharge absolute humidity control is to adjust the humidity so as to achieve the discharge setpoint determined by the value from the return humidity sensor. The discharge humidity setpoint is calculated by the control loop, which is then used to regulate the discharge humidity using humidification or dehumidification functions. An absolute (not relative) humidity sensor connected on the discharge air is required to perform this function.
9. The function of the fixed-value absolute humidity discharge control is to adjust the humidity so as to achieve the HumSpt as the discharge setpoint (by default, 55%) using

the humidification or dehumidification function. An absolute (not relative) humidity sensor connected on the discharge air is required to perform this function.

10. The humidity control function has two independent control loops, one for humidification control directly controlling the humidifier connected to the A1 output of the AAC20 controller (Humidifier Control Signal), and the other for dehumidification control affecting the control of the cooler connected to the A2 output of the AAC20 controller (Cooling Valve). The maintenance of the previously reduced temperature to the set level according to the temperature control is done by controlling the secondary heater connected to the A2 output of the 4U4A-H or MIX18 module (ReHeating Valve).
11. Both humidification and dehumidification control functions ramp up gradually at the speed of HUM_RampUp (by default, 10%/min) and DEH_RampUp (by default, 10%/min), respectively.
12. The HumSpt set humidity (by default, 55%) can take into account either winter compensation determined by a linear function in relation to the outside temperature from RAH_MinHumSpt (by default, 30%Rh) to HumSpt (by default, 55%) or summer compensation determined by a linear function in relation to the outside temperature from HumSpt (by default, 55%) to RAH_MaxHumSpt (by default, 60%Rh).
13. Depending on the type of humidifier selected in HumidifierMode, the A3 output control in the 4U4A-H or MIX18 module (Humidifier Start Command) is activated as required: as a water humidifier pump (mode 1) or as switched on permanently (if there is no failure) during AHU operation as a steam humidifier enabler (mode 2).
14. In case of a humidifier failure activated at the U3 input of the 4U4A-H module or at the I1 input of the MIX18 module (Humidifier Fault), the humidifier control is turned off, the water humidifier pump/steam humidifier is shut down, and an alarm is generated at the O4 output of the MIX18 module (Humidifier Failure Alarm).
15. In addition to the hygrostat connected to the I3 input of the MIX 18 module (Hygrostat), which, when activated, turns off the humidification function (turns off the humidifier and pump / permit control), there is also a function to protect the occurrence of too much discharge humidity (to prevent the ducts from getting wet). If the discharge air humidity begins to increase towards the DAH_MaxSpt value (by default, 90%), then the humidifier control gradually decreases to zero.
16. Deactivation of the humidistat or humidifier failure automatically resets the alarm and returns to normal control mode.

8.6.3 Electrical Connections



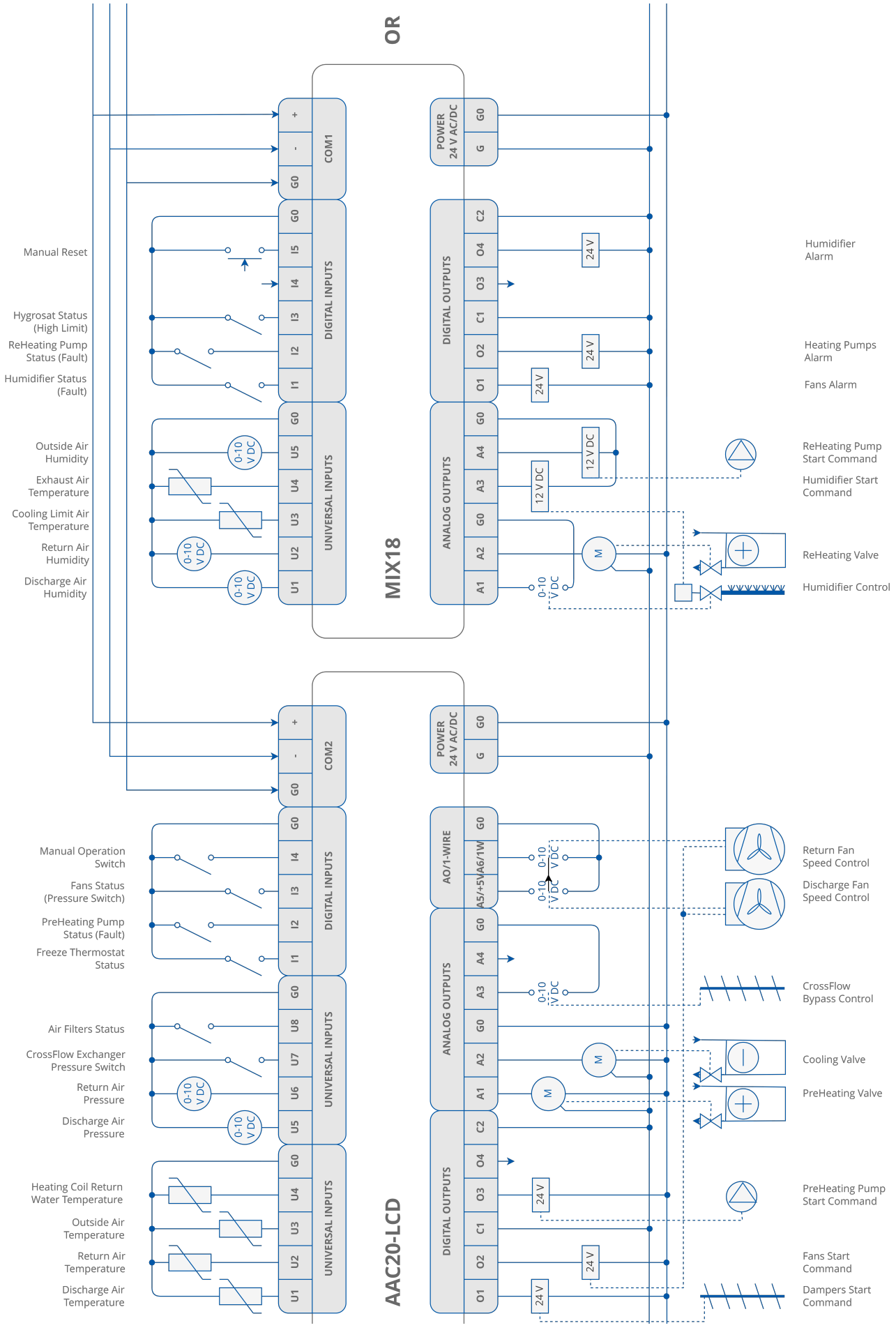

OR
MIX18
AAC20-LCD
COM1
COM2
POWER 24 V AC/DC
DIGITAL INPUTS
DIGITAL OUTPUTS
UNIVERSAL INPUTS
ANALOG OUTPUTS
AO/1-WIRE
Manual Reset
Hygrosat Status (High Limit)
ReHeating Pump Status (Fault)
Humidifier Status (Fault)
Outside Air Humidity
Exhaust Air Temperature
Cooling Limit Air Temperature
Return Air Humidity
Discharge Air Humidity
Humidifier Alarm
Heating Pumps Alarm
Fans Alarm
ReHeating Pump Start Command
Humidifier Start Command
ReHeating Valve
Humidifier Control
Manual Operation Switch
Fans Status (Pressure Switch)
PreHeating Pump Status (Fault)
Freeze Thermostat Status
Air Filters Status
CrossFlow Exchanger Pressure Switch
Return Air Pressure
Discharge Air Pressure
Heating Coil Return Water Temperature
Outside Air Temperature
Return Air Temperature
Discharge Air Temperature
Return Fan Speed Control
Discharge Fan Speed Control
CrossFlow Bypass Control
Cooling Valve
PreHeating Valve
PreHeating Pump Start Command
Fans Start Command
Dampers Start Command

Figure 92. Electrical connections for supply and exhaust air handling unit with cross-flow exchanger, water heaters and water cooler, with humidification and dehumidification function

8.7 Example 7

8.7.1 Supply and Exhaust Air Handling Unit with Mixing Dampers, Water Heaters and Water Cooler, with Humidification and Dehumidification Function

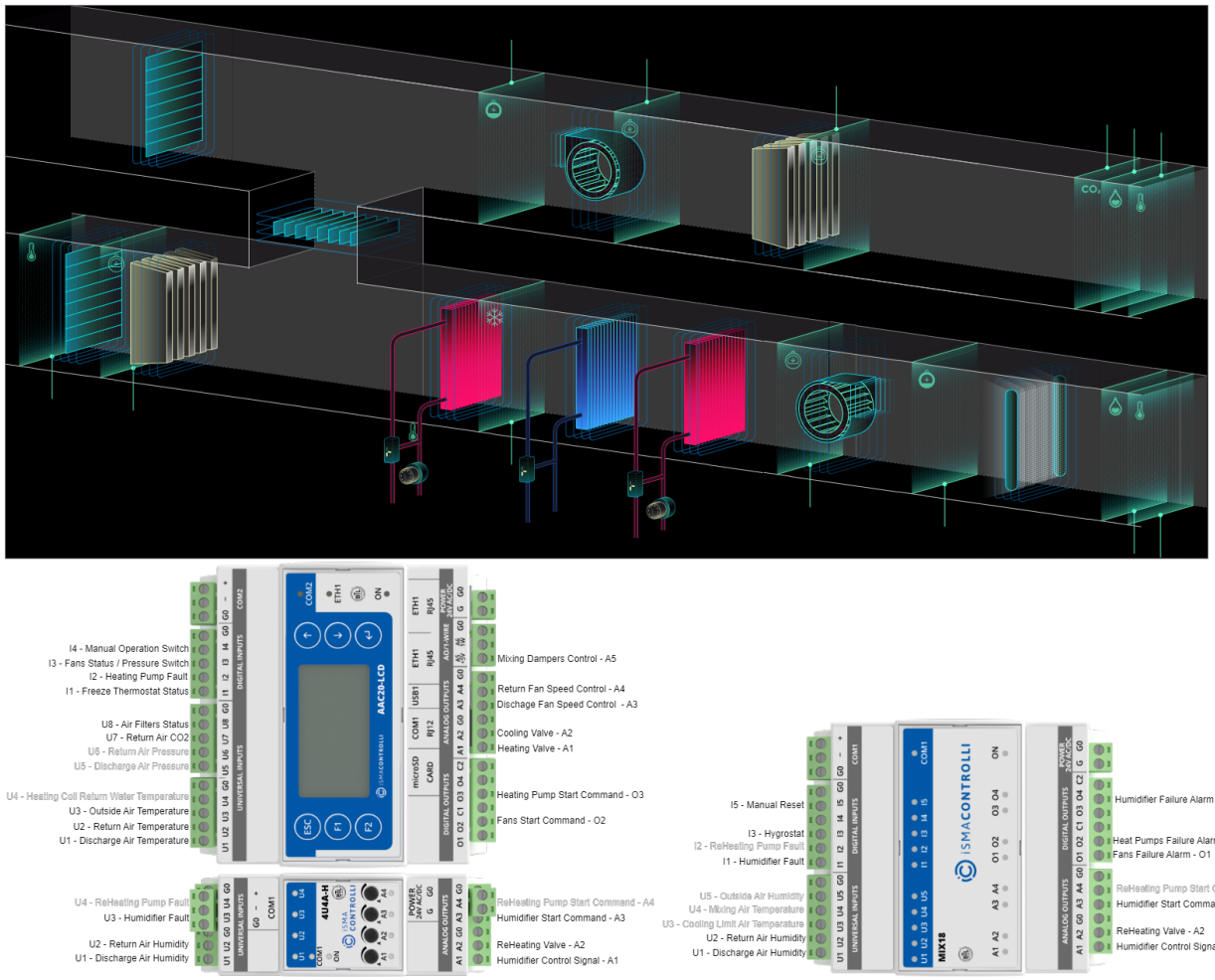


Figure 93. Inputs and outputs configured for supply and exhaust air handling unit with mixing dampers, water heaters and water cooler, with humidification and dehumidification function

The air handling unit consists of:

- mixing inlet, outlet and return damper;
- air supply and exhaust filter;
- water preheater with a valve and a preheater pump;
- water cooler with a valve;
- water reheater with a valve and, optionally, a reheater pump;
- supply and exhaust fans controlled by an inverter;
- humidifier.

The AAC20 controller is sufficient if the dehumidification and humidification functions are not used. To enable humidity control, it is required to add an additional extension I/O module, iSMA-B-4U4A or -MIX18, to the AAC20 controller (depending on the demand and required sensors/signals).

The required sensors/signals are:

- discharge air temperature sensor;
- return air temperature sensor;
- outside air temperature sensor;
- discharge air humidity sensor (for humidification and dehumidification functions);
- return air humidity sensor (for humidification and dehumidification functions);
- anti-freeze thermostat;
- humidifier failure status (if is required and exist, can be used in conjunction with a hygrostat for the MINI module);
- hygrostat (if is required and is installed);
- fans operating status (pressure switch, signal from the inverter) – connected in series;
- manual switch control (permission to operate the ventilation system).

Some of the useful sensors/signals, optional but not required:

- preheat pump failure status;
- reheat pump failure status (if reheat pump is installed);
- filters dirty status (for monitoring only) – connected in parallel;
- manual reset (for MIX18 only, in case of manual fault reset).

In addition, the system can be equipped with extra sensors/signals, such as:

- return air CO2 sensor;
- outside air humidity;
- mixing air temperature;
- heater return water temperature;
- cooler limit air temperature;
- discharge air pressure sensor (only when there is a need to maintain constant pressure on the supply duct);
- return air pressure sensor (only when there is a need to maintain constant pressure on the exhausts duct).

The application allows for:

- controlling the modulating (analog 0-10 V DC) of the mixing inlet, outlet, and return dampers:
- the fans to start and controlling their speed (constant or pressure dependent);
- controlling the modulating (analog 0-10 V DC) preheater valve actuator and the preheater pump;
- controlling the modulating (analog 0-10 V DC) reheater valve actuator (used for the dehumidification function) and, optionally, a reheater pump;
- controlling the modulating (analog 0-10 V DC) cooler valve actuator;
- the humidifier to start and controlling its humidification performance.

If the MIX18 module is used, it is also possible to signal alarm states for the fans (common alarm), heaters pump (common alarm), and humidifier.

AHU configuration example:

- heater mode – PreHeater & ReHeater [2]

- energy recovery mode – **Mixing Dampers [3]**
- cooler mode – **Cooler [1]**
- humidifier mode – **Water Humidifier or Steam Humidifier [1 or 2]** (depending on the need)
- economizer mode – **None, Eco Return Temp or Eco Enthalpy [0, 1 or 2]** (depending on the need)
- temperature control mode – **Cascade Temp, Constant Disch Temp or Comfort Zone Temp [1, 2 or 3]** (depending on the need)
- humidity control mode – **Comfort Hum, Return Hum, Disch Abs Hum or Constant Disch Abs Hum [1, 2, 3 or 4]** (depending on the need)

8.7.2 Application Algorithm Description

Start-up

1. The first step after configuring the application for a particular type of the AHU is to make sure that the time schedule is correctly configured, which allows the AHU to run in a normal mode (Plant Mode as Occupied Period [4]) or in a night mode (with reduced efficiency - Plant Mode as Night Cycle [2]). If not, the time schedule must first be set correctly to allow a proper AHU operation.
2. The signal that allows the AHU to start is the signal connected to the I4 input of the AAC20 (Operating Switch). Activating this signal (physical short circuit at the input) and correctly setting the time schedule allows the AHU to start, while deactivating the signal automatically stops the AHU.

Preheater

1. The next step before starting the AHU is for the controller to verify that the heater has no active alarm conditions associated with the antifreeze protection procedure.
2. The antifreeze protection of the heater is used in the winter period (when the outside temperature is lower than the limit set by OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K).
3. The basic element is the antifreeze thermostat whose physical setting should be in accordance with or slightly lower than the above limit (e.g., by 1°C). The antifreeze thermostat is connected to the I1 input on the AAC20 controller (Freeze Thermostat Status).
4. Activation of the antifreeze thermostat (physical short circuit at the input) triggers the antifreeze protection procedure consisting of stopping the AHU (turning off the fans and closing the inlet and outlet dampers), opening the heater valve on the A1 output of the AAC20 controller (Heating Valve) to the level specified in HTV_FrostProt_ValveUp (default 100%), and switching on the heater pump on the O3 output (Heating Pump Start Command) if configured for use by HPU_Enable (active by default - true).
5. An additional element of antifreeze protection is the use of a return water temperature sensor connected to the U4 input in the AAC20 (Heating Coil Return Water Temperature). If the antifreeze thermostat is triggered, the setpoint for the return water temperature is raised additionally by the level specified in FEZ_RWT_SptUp (by default, 15K).
6. When the temperature of the heater rises and the antifreeze thermostat returns to the normal state, In such case, if there is a sensor for the water temperature at the return from the heater, its setpoint will begin to fall at the rate of FEZ_SetupRamp

(default 1K/min) to the normal setpoint (calculated on the basis of the outside temperature); if there is no sensor, the valve closes at the rate of HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current system control.

7. The heater return water temperature sensor also serves as a high limit for the water temperature in the heater by closing the valve if the temperature specified in RWT_MaxSetpoint is too high (85°C by default).
8. If the pump is activated in HPU_Enable (active by default - true) and connected to the O3 output in the AAC20 (Heating Pump Start Command), it is switched on with the delay HPU_OnDelay (by default, 5 s) when the heater valve connected to the A1 output in the AAC20 (Heating Valve) opens to 3% or more, and switched off with the delay specified in HPU_OffDelay (by default, 300 s) when the valve is opened 1% or less.
9. In winter, the pump is permanently activated if the outside temperature falls below the OAT_FrostProtection limit (by default, 6°C) with a central hysteresis of 1K and if the antifreeze thermostat is activated.
10. When using the pump failure signal, which is connected to the I2 input on the AAC20 (Heating Pump Fault), and when the value in HPU_StatusAlarmDelay (by default, 1 s) is set to default, then in the winter period the AHU can be turned off if:
    a. DME_EmergencyStop (deactivated by default - false) is active (set to true),
    b. an alarm is generated on the O2 output of the MIX18 module (Heat Pumps Failure Alarm), and
    c. the pump control output is turned off.
    The alarm is automatically reset if the signal at the input is deactivated and the pump and AHU system resume operation (if stopped).
11. An additional feature to ensure a proper and long-lasting operation of the devices operating the heater is exercising the pump and valve. First, the pump is exercised, then the valve, which, by default, takes place every Sunday at 1am in case they are not in use. The exercise consists of turning on the pump for the time specified in HPU_Pmp_Vlv_Exercise (120 s by default) and then opening the valve to 100% for the same time as above.

Dampers

1. In winter, when the outside temperature is lower than the limit specified by OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K and the return water temperature sensor is used, then, it must reach the setpoint (calculated from the outside temperature) to allow the dampers to open after the time specified in DME_OnDelay (by default, 300 s).
2. If the return water temperature sensor from the heater is not used, the dampers are opened only after the time specified in DME_OnDelay (by default, 300 s), during which the valve is opened according to the HTV_FrostProt_ValveUp parameter (by default, 100%) and drops at the rate specified by HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current system control.
3. When the outside temperature is above the limit specified in OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K (summer period), the dampers are opened without the delay specified in DME_OnDelay (by default, 300 s) and the heater return water temperature is not controlled at that time.
4. Dampers connected to the A5 output in the AAC20 (Mixing Dampers Control) start the opening control procedure after the time specified in DME_OnDelay (by default, 300 s)

only after the permission from the heater operating normally, and then the signal from the dampers are transmitted directly without delay as a start permission for the fans.
5. In winter (when the outside temperature is lower than the limit specified by the OAT_FrostProtection parameter, by default, 6°C), with a central hysteresis of 1K, the AHU always starts with the inlet and outlet dampers closed and the mixing damper open for the time specified in MAD_RecircTimeStart (by default, 600 s), and then proceeds to normal control of opening the dampers.
6. The AHU controls the inlet and outlet dampers, and the mixing damper must be set to a reverse control on the damper actuator.
7. In addition, when using a temperature sensor connected to the U4 input of the MIX18 (Mixing Air Temperature) module located on the supply air after the mixing damper, it is possible to maintain the setpoint temperature in the range of MAT_MinSetpoint (by default, 10°C) to MAT_MaxSetpoint (by default, 15°C), calculated compensatively from the outdoor temperature, which serves to protect the preheater from freezing.
8. If there is no temperature sensor downstream of the mixing damper, the limitation of opening of the dampers (inlet and outlet) is compensated from the outside temperature directly with the minimum proportion of outside air specified by DMS_MinPosition (by default, 20%).

Fans

1. If pressure sensors is connected at the U5 and U6 input in the AAC20 (Discharge Air Pressure, Return Air Pressure), each fan in is controlled smoothly connected at the A3 or A4 output in the AAC20 (Discharge Fan Speed Control, Return Fan Speed Control) in the range from FSC_MinSignal (by default, 30%) to FCS_MaxSignal (by default, 100%) so as to maintain the set pressures, or is controlled from the control signal resulting from humidity and air quality control, or manually with a set speed in the above ranges in the absence of connected pressure sensors (the higher control value is selected).
2. Each fan has its preset DischPressSpt pressure (500 Pa by default) and ReturnPressSpt pressure (500 Pa by default), which it is supposed to maintain by adjusting its speed accordingly.
3. Fans connected to the O2 output in the AAC20 (Fans Start Command) start with the delay specified in FSC_OffOnDelay (by default, 5 s) after receiving a permission from the dampers.
4. After receiving the startup permission, the fan speed control signal slowly ramps up at the rate of FSC_Ramp (by default, 1%/min) to the desired value resulting from the corresponding control as indicated above. The rate of rise or fall of the control signal is determined by the same speed.
5. The pressure setpoint behaves similarly, which during the AHU startup ramps up from zero to the desired setpoint at the speed of DSP_PressSptRamp (by default, 50 Pa/min). If it is changed during a normal operation, it will correspondingly start falling or rising at the same speed specified in DSP_PresSptRamp (by default, 50 Pa/min).
6. For a night mode, the set pressure is reduced by multiplying it by the DSP_NightReduce factor (by default, 50%).
7. To protect the fans operation, a fans confirmation signal is connected to the I3 input in the AAC20 (Fans Status/Pressure Switch), which if not activated by the time FDP_BeltAlarmDelay (default 120s), then, an alarm is generated on the O1 output of MIX18 (Fans Failure Alarm) and this causes the AHU to stop. This function can be disabled by setting the zero value in FDP_BeltAlarmDelay (by default, 120 s).

8. In the automatic reset mode specified in FSC_ManualReset (by default, false), after an alarm from the fan, the alarm will be reset and the AHU will resume operation, while after three unsuccessful attempts to start, the system stops and in the automatic mode it can be reset by removing and reactivating the I4 input in AAC20 (Operating Switch). While if the manual reset mode specified in FSC_ManualReset (deactivated - false by default) is set to true, after an alarm from the fan the AHU will be stopped and the controller will wait for a reset signal activated by the input connected to the I5 input in MIX18 (Reset) and only then will it attempt to restart the AHU.

Control

1. In winter, during the AHU startup, the temperature control system temporarily raises the setpoint for the discharge temperature by an additional value specified in DAT_SptRamp (by default, 1K) which drops in time specified in DAT_SptDecTime (by default, 600 s).
2. The application allows to configure the TempCtrlMode temperature control function in 3 modes described below.
3. The cascade control function consists of regulating the discharge temperature connected to the U1 input of the AAC20 (Discharge Air Temperature), whose setpoint is determined by the control loop of the return temperature connected to the U2 input of the AAC20 (Return Air Temperature) and the setpoint of the return temperature TempSpt (by default, 22°C) in the heating or cooling function (with the exchanger as the first stage in both cases or without), as well as the fan speed allowing the fans to run above the value derived from RT_DATSpt_shift (by default, 60%), as long as pressure control is not used and the manual setting is lower than that derived from the temperature control function.
4. The fixed-value temperature control function consists of adjusting the discharge air temperature connected at the U1 input of the AAC20 controller (Discharge Air Temperature) based on the set TempSpt temperature (by default, 22°C), and based on the control loop the control level for the heater or cooler and exchanger is calculated.
5. The cascade control function with comfort zone consists of adjusting the discharge air temperature connected at the U1 input of the AAC20 (Discharge Air Temperature) to achieve a set discharge air temperature separate for the heating and cooling functions, taking into account the RT_ComfortZone comfort zone between them (the optimal zone in which heating and cooling are not adjusted – by default, 2°C). The setpoint of discharge temperature is the output from the return temperature control system connected to the U2 input of the AAC20 controller (Return Air Temperature) to achieve the set temperature defined by the TempSpt variable (default 22°C). In addition, the discharge air temperature control system can affect the speed of the fans by allowing them to run above the value derived from RT_DATSpt_shift (by default, 60%), unless pressure control is used or the manual speed setting is lower than that derived from the discharge air temperature control function.
6. For the cascade function with comfort zone, the heat or cooling recovery system works in the comfort zone by controlling the exchanger accordingly. When using the economizer function, the control signal can be reversed.
7. The setpoint of discharge temperature is calculated from DAT_LowSetpoint (by default, 14°C) to DAT_HighSetpoint (by default, 26°C).
8. If the discharge air temperature falls below the low limit, the cooler is gradually closed, the heat exchanger begins to work on heat recovery, and the heater begins to open.

9. If the discharge air temperature rises above the high limit, the heater is gradually closed, the heat exchanger begins to work on the recovery of cooling, and the cooler begins to open.
10. The TempSpt set temperature (by default, 22°C) can take into account the winter compensation specified by the WC_DischSptRaise parameter (by default, 4K) or the summer compensation specified by the SC_DischSptRaise parameter (by default, 4K).
11. In the case of a night temperature drop, the RT_ComfortZone comfort zone is expanded four times.
12. In the case of active humidification function, the fan speed can gradually increase with the humidifier control signal, as long as pressure control is not used and the manual setting is lower than the humidification control function.
13. In the case of active dehumidification function using an economizer in mode 2, the inlet and outlet dampers are opened first (and the mixing damper is closing), then the fan speed is gradually increased (with attention to the above), and the cooler is opened in turn.
14. When the absolute humidity outside is higher than that of the return, the sequence changes, causing the cooler to open first, and then increase the speed of the fan (with a note as above), the dampers are not involved in this case.
15. In summer, if the outside temperature rises above the OAT_HeaterLimit (by default, 20°C), heater control is blocked, and in winter, if the outside temperature falls below the OAT_CoolerLimit (by default, 14°C), cooler control is blocked.
16. When the antifreeze protection is triggered, all control signals are reset except for the signal for the heater which is set to the level specified in HTV_FrostProt_ValveUp (by default, 100%). When the risk of freezing ceases, all signals return to normal operation.
17. The heater valve is opened or closed by the valve actuator according to the control signal coming from the temperature control system according to the configured TempCtrlMode.

Reheater

1. When HeaterMode (mode 2) is selected as operation mode for both primary and secondary heaters, then when the humidification function is active, only the primary heater works, and when the dehumidification function is in operation, only the secondary heater is used for temperature control.
2. If no humidity control is used (or no active humidification or dehumidification function), both heaters work simultaneously in the temperature control function, but can be configured as needed for gradual operation (the primary heater is the first stage, and the secondary is the second).
3. If the secondary heater pump is activated in HPU_Enable (active by default - true) and connected to the A4 output of the module 4U4A-H or MIX18 (ReHeating Pump Start Command), it is switched on with the delay HPU_OnDelay (by default, 5 s) when the secondary heater valve connected to the A2 output in the module 4U4A-H or MIX18 (ReHeating Valve) opens to 3% or more, and is switched off with the delay specified in HPU_OffDelay (by default, 300 s) when the valve is opened 1% or less.
4. In winter, when the outdoor temperature drops below the OAT_FrostProtection value (by default, 6°C) at the start of the AHU system, the secondary heater valve opens according to the HTV_FrostProt_ValveUp parameter (by default, 100%) and drops at the rate specified by HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current system control.

5. In winter, the secondary heater pump is permanently activated if the outdoor temperature falls below the OAT_FrostProtection limit (by default, 6°C) with a central hysteresis of 1K.
6. When using the secondary heater pump failure signal which is connected to the U4 input of the module 4U4A-H or the I2 input of the module MIX18 (ReHeating Pump Fault) and when the value in HPU_StatusAlarmDelay (by default, 1 s) is set to default, an alarm is generated on the O2 output of the module MIX18 (Heat Pumps Failure Alarm) and the pump control output is disabled. The alarm is automatically reset if the input signal is deactivated and the pump resumes operation.
7. An additional feature to ensure a proper and long-lasting operation of the devices operating the secondary heater is exercising the pump and valve. First, the pump is exercised, then the valve, which, by default, takes place every Sunday at 1am in case they are not in use. The exercise consists of turning on the pump for the time specified in HPU_Pmp_Vlv_Exercise (120 s by default) and then opening the valve to 100% for the same time as above.

Cooler

1. When cooling is needed, the cooler valve connected to the A2 output (Cooling Valve) opens based on a stronger signal coming from the temperature control system or dehumidification function.
2. The control of the cooler valve is blocked below the OAT_CoolerLowLimit temperature (by default, 14°C) with a central hysteresis of 1K.
3. It is possible to block the control of the cooler valve in the humidification function with the CCV_CoolOnHumDisable parameter (active by default – true).
4. During the AHU startup and each time the valve is opened from zero, the control signal gradually increases at the rate specified in CCV_VlvRamp (by default, 5%/min).
5. To protect against too low air temperature behind the cooler, it is possible to use a temperature sensor connected to the U3 input on the MIX18 module (Cooling Limit Air Temperature) causing the cooler valve to gradually close when the temperature drops to the LIM_Setpoint value (by default, 14°C).
6. An additional feature to ensure a proper and long-lasting operation of the cooler is exercising the valve. It is carried out by default every Sunday at 1am in case it is not being used. Exercise consists of opening the valve to 100% for the time specified in CCV_Vlv_Exercise (120 s by default).

Exchanger

1. In order to increase energy efficiency, the AHU system is additionally equipped with system with mixing damper to recover thermal energy (heat or cold) from either return or outside air in order to use this energy to heat or cool the incoming outside air.
2. One of five types of exchanger can be selected in EnergyRecovMode. Type 3 indicates mixing dampers.
3. The dampers are controlled at the A5 output of the AAC20 (Mixing Dampers Control) primarily from the temperature control system, but their control is also affected by the economizer function, humidity control or air quality control.
4. To regulate the quality of exhaust air, a CO2 sensor connected to the U7 input in the AAC20 controller (Return Air CO2) is used, which causes the control signal of the dampers (mixing) to reduce, at the same time increasing the share of outside air

(intake and outlet) in case of rising levels of CO2 concentration in relation to the set CO2Setpoint (by default, 600 ppm), and vice versa.

Economizer

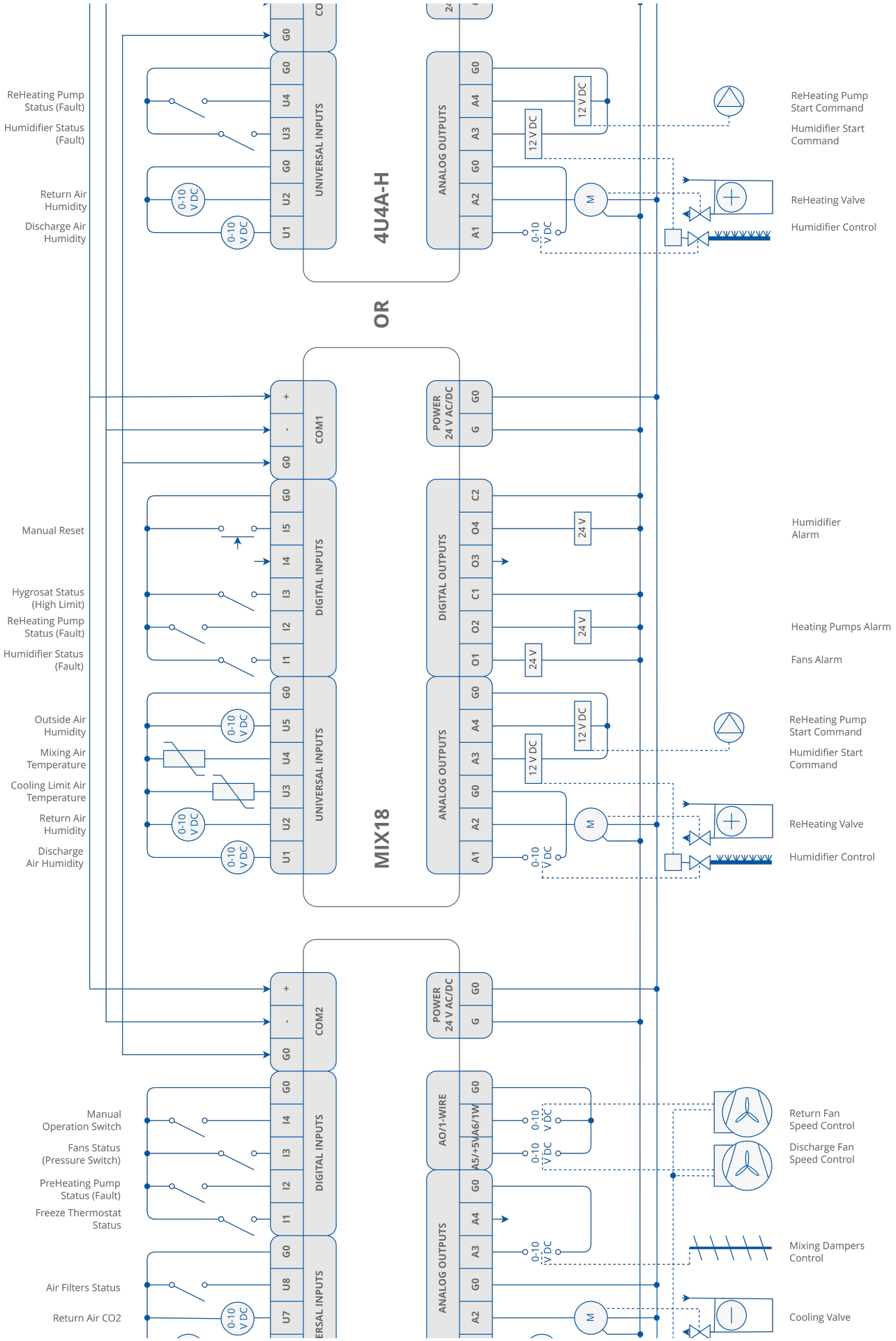
1. In addition, an economizer function is used to support energy efficiency, the mode of which can be set in EconomizerMode.
2. The Economizer in operation mode 1 compares only the outdoor and return temperatures to determine the optimal signal for energy recovery by the mixing dampers.
3. In mode 2, the economizer determines the energy recovery function based on measurements of outdoor and return temperatures and humidity, deciding in the summer using the calculated enthalpy and absolute humidity which air flow to use for cooling (exhaust or fresh), and in the case of an AHU system, sets the minimum share of fresh air if the enthalpy of outdoor air is higher than that of return air.
4. Calculations based on absolute humidity apply only when using the dehumidification function.
5. Both functions, enthalpy and absolute humidity, are triggered when the appropriate conditions are met taking into account the central hysteresis of EnthalpyDiff (by default, 5kJ/kg) and AbsHumDiff (by default, 1g/kg) respectively, with a delay specified by SwitchoverDel (by default, 300s).
6. Air quality control (CO2 concentration) has a higher priority over the economizer function.

Humidifier

1. The AHU is also equipped with a humidification and dehumidification function. The humidification function is started with a delay of HUM_FanOnDelay (by default, 300 s) after confirming the operation of the fans connected to the I3 input in the AAC20 (Fans Status/Pressure Switch).
2. In case of lack of confirmation that the fans connected to the I3 input of the AAC20 (Fans Status/Pressure Switch) is operating, the humidification function is turned off immediately.
3. The humidification function is active when the outdoor temperature is lower than the OAT_HighHum parameter (by default, 14°C), and the dehumidification function is active when the outdoor temperature is higher than the OAT_LowDeh parameter (by default, 15°C).
4. To implement humidity control, a discharge air sensor connected to the U1 input of the 4U4A-H or MIX18 (Discharge Air Humidity) module and an return air sensor connected to the U2 input of the 4U4A-H or MIX 18 (Return Air Humidity) module are required, depending on the selected humidity control function.
5. The application allows to configure the HumCtrlMode humidity control function in 4 modes described below.
6. The function of return relative humidity control with comfort zone (optimal zone in which humidification and dehumidification control does not take place) is to regulate humidity so as to achieve HumSpt as the setpoint for return (by default, 55%) taking into account the comfort zone HUMDEH_ComfZone (by default, 4%) using humidification or dehumidification function. The comfort zone is quadrupled in the case of night temperature drop.

7. The function of controlling the return relative humidity without comfort zone is to adjust the humidity to achieve the HumSpt as the setpoint for the return (by default, 55%) using the humidification or dehumidification function.
8. The function of the discharge absolute humidity control is to adjust the humidity so as to achieve the discharge setpoint determined by the value from the return humidity sensor. The discharge humidity setpoint is calculated by the control loop, which is then used to regulate the discharge humidity using humidification or dehumidification functions. An absolute (not relative) humidity sensor connected on the discharge air is required to perform this function.
9. The function of the fixed-value absolute humidity discharge control is to adjust the humidity so as to achieve the HumSpt as the discharge setpoint (by default, 55%) using the humidification or dehumidification function. An absolute (not relative) humidity sensor connected on the discharge air is required to perform this function.
10. The humidity control function has two independent control loops, one for humidification control directly controlling the humidifier connected to the A1 output of the AAC20 controller (Humidifier Control Signal), and the other for dehumidification control affecting the control of the cooler connected to the A2 output of the AAC20 controller (Cooling Valve). The maintenance of the previously reduced temperature to the set level according to the temperature control is done by controlling the secondary heater connected to the A2 output of the 4U4A-H or MIX18 module (ReHeating Valve).
11. Both humidification and dehumidification control functions ramp up gradually at the speed of HUM_RampUp (by default, 10%/min) and DEH_RampUp (by default, 10%/min), respectively.
12. The HumSpt set humidity (by default, 55%) can take into account either winter compensation determined by a linear function in relation to the outside temperature from RAH_MinHumSpt (by default, 30%Rh) to HumSpt (by default, 55%) or summer compensation determined by a linear function in relation to the outside temperature from HumSpt (by default, 55%) to RAH_MaxHumSpt (by default, 60%Rh).
13. Depending on the type of humidifier selected in HumidifierMode, the A3 output control in the 4U4A-H or MIX18 module (Humidifier Start Command) is activated as required: as a water humidifier pump (mode 1) or as switched on permanently (if there is no failure) during AHU operation as a steam humidifier enabler (mode 2).
14. In case of a humidifier failure activated at the U3 input of the 4U4A-H module or at the I1 input of the MIX18 module (Humidifier Fault), the humidifier control is turned off, the water humidifier pump/steam humidifier is shut down, and an alarm is generated at the O4 output of the MIX18 module (Humidifier Failure Alarm).
15. In addition to the hygrostat connected to the I3 input of the MIX 18 module (Hygrostat), which, when activated, turns off the humidification function (turns off the humidifier and pump / permit control), there is also a function to protect the occurrence of too much discharge humidity (to prevent the ducts from getting wet). If the discharge air humidity begins to increase towards the DAH_MaxSpt value (by default, 90%), then the humidifier control gradually decreases to zero.
16. Deactivation of the humidistat or humidifier failure automatically resets the alarm and returns to normal control mode.

8.7.3 Electrical Connections


4U4A-H
OR
MIX18
UNIVERSAL INPUTS
DIGITAL INPUTS
ANALOG OUTPUTS
DIGITAL OUTPUTS
POWER 24 V AC/DC
COM1
COM2
AO/1-WIRE
ReHeating Pump Status (Fault)
Humidifier Status (Fault)
Return Air Humidity
Discharge Air Humidity
Manual Reset
Hygrosat Status (High Limit)
Outside Air Humidity
Mixing Air Temperature
Cooling Limit Air Temperature
Manual Operation Switch
Fans Status (Pressure Switch)
PreHeating Pump Status (Fault)
Freeze Thermostat Status
Air Filters Status
Return Air CO2
ReHeating Pump Start Command
Humidifier Start Command
ReHeating Valve
Humidifier Control
Humidifier Alarm
Heating Pumps Alarm
Fans Alarm
Return Fan Speed Control
Discharge Fan Speed Control
Mixing Dampers Control
Cooling Valve

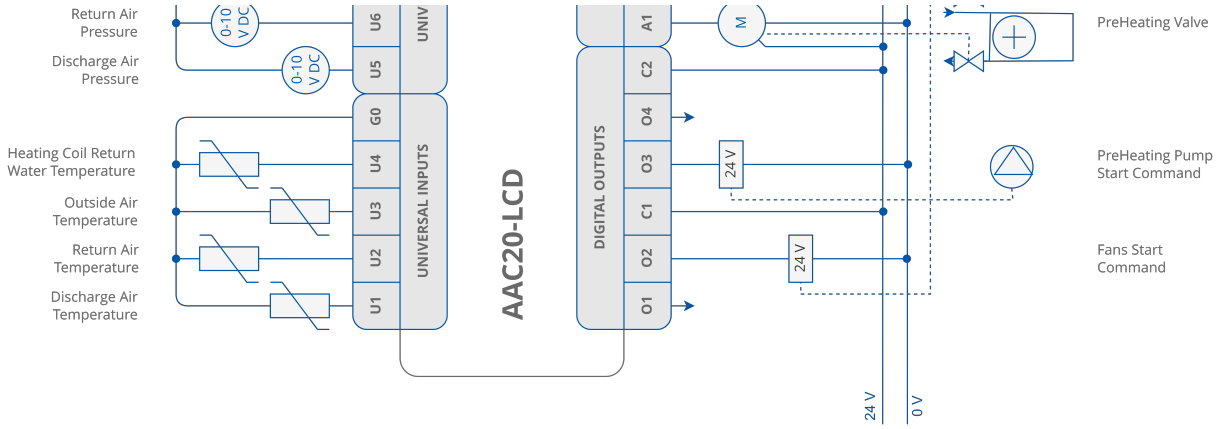
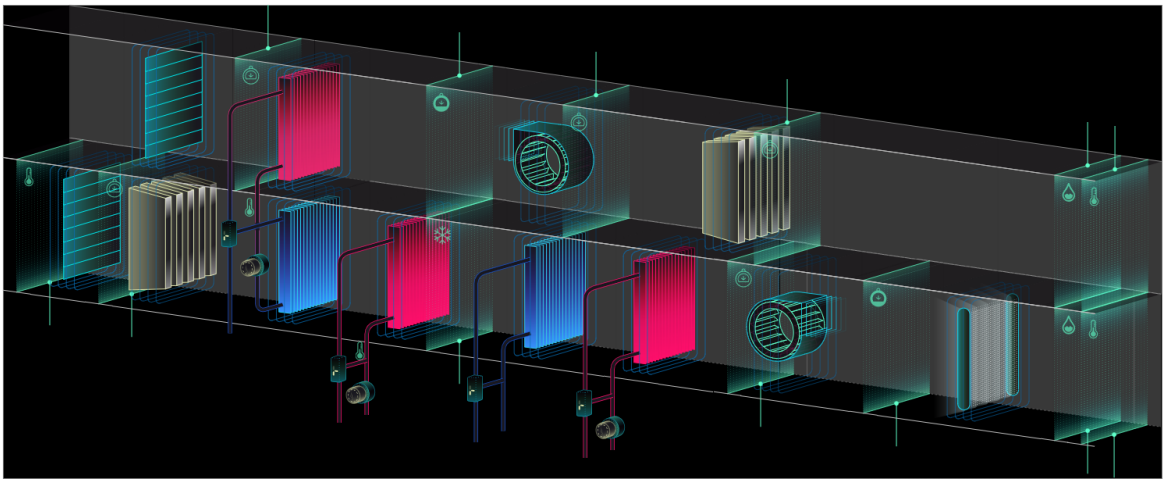


Figure 94. Electrical connections for supply and exhaust air handling unit with mixing dampers, water heaters and water cooler, with humidification and dehumidification function

8.8 Example 8

8.8.1 Supply and Exhaust Air Handling Unit with Twin-coil Exchanger, Water Heaters and Water Cooler, with Humidification and Dehumidification Function



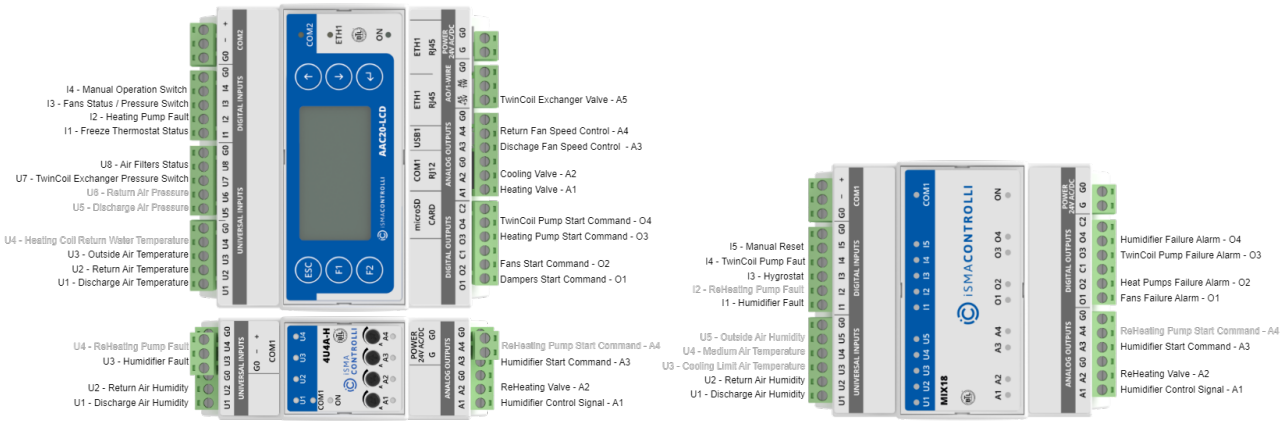


Figure 95. Inputs and outputs configured for supply and exhaust air handling unit with twin-coil exchanger, water heaters and water cooler, with humidification and dehumidification function

The air handling unit consists of:

- 2-position inlet and outlet damper;
- air supply and exhaust filter

- twin-coil exchanger with a valve and exchanger pump;
- water preheater with a valve and a preheater pump;
- water cooler with a valve;
- water reheater with a valve and, optionally, a reheater pump;
- supply and exhaust fans controlled by an inverter;
- humidifier.

The AAC20 controller is sufficient if the dehumidification and humidification functions are not used. To enable humidity control, it is required to add an additional extension I/O module, iSMA-B-4U4A or -MIX18, to the AAC20 controller (depending on the demand and required sensors/signals).

The required sensors/signals are:

- discharge air temperature sensor;
- return air temperature sensor;
- outside air temperature sensor;
- twin-coil exchanger pressure switch;
- discharge air humidity sensor (for humidification and dehumidification functions);
- return air humidity sensor (for humidification and dehumidification functions);
- anti-freeze thermostat;
- humidifier failure status (if is required and installed, can be used in conjunction with a hygrostat for the MINI module);
- hygrostat (if is required and installed);
- fans operating status (pressure switch, signal from the inverter) – connected in series;
- manual switch control (permission to operate the ventilation system).

Some of the useful sensors/signals, optional but not required:

- preheat pump failure status;
- reheat pump failure status (if a reheat pump is installed);
- filters dirty status (for monitoring only) – connected in parallel;
- manual reset (for MIX18 only, in case of manual fault reset).

In addition, the system can be equipped with extra sensors/signals, such as:

- outside air humidity;
- heater return water temperature;
- exchanger medium temperature;
- cooler limit air temperature;
- discharge air pressure sensor (only when there is a need to maintain constant pressure on the supply duct);
- return air pressure sensor (only when there is a need to maintain constant pressure on the exhausts duct).

The application allows for:

- controlling the opening/closing of the 2-position inlet and outlet dampers;
- the fans to start and controlling their speed (constant or pressure dependent)
- controlling the modulating (analog 0-10 V DC) twin-coil valve actuator and the exchanger pump;
- controlling the modulating (analog 0-10 V DC) preheater valve actuator and the preheater pump;
- controlling the modulating (analog 0-10 V DC) reheater valve actuator (used for the dehumidification function) and, optionally, the reheater pump;

- controlling the modulating (analog 0-10 V DC) cooler valve actuator;
- the humidifier to start and controlling its humidification performance.

If the MIX18 module is used, it is also possible to signal alarm states for the fans (common alarm), heaters pump (common alarm), twin-coil pump and humidifier.

AHU configuration example:

- heater mode – **PreHeater & ReHeater [2]**
- energy recovery mode – **Twin Coil & Return Pump or Twin Coil & Supply Pump [4 or 5]** (depending on the need);
- cooler mode – **Cooler [1]**;
- humidifier mode – **Water Humidifier or Steam Humidifier [1 or 2]** (depending on the need)
- economizer mode – **None, Eco Return Temp or Eco Enthalpy [0, 1 or 2]** (depending on the need)
- temperature control mode – **Cascade Temp, Constant Disch Temp or Comfort Zone Temp [1, 2 or 3]** (depending on the need)
- humidity control mode – **Comfort Hum, Return Hum, Disch Abs Hum or Constant Disch Abs Hum [1, 2, 3 or 4]** (depending on the need)

8.8.2 Application Algorithm Description

Start-up

1. The first step after configuring the application for a particular type of the AHU is to make sure that the time schedule is correctly configured, which allows the AHU to run in a normal mode (Plant Mode as Occupied Period [4]) or in a night mode (with reduced efficiency - Plant Mode as Night Cycle [2]). If not, the time schedule must first be set correctly to allow a proper AHU operation.
2. The signal that allows the AHU to start is the signal connected to the I4 input of the AAC20 (Operating Switch). Activating this signal (physical short circuit at the input) and correctly setting the time schedule allows the AHU to start, while deactivating the signal automatically stops the AHU.

Preheater

1. The next step before starting the AHU is for the controller to verify that the heater has no active alarm conditions associated with the antifreeze protection procedure.
2. The antifreeze protection of the heater is used in the winter period (when the outside temperature is lower than the limit set by OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K).
3. The basic element is the antifreeze thermostat whose physical setting should be in accordance with or slightly lower than the above limit (e.g., by 1°C). The antifreeze thermostat is connected to the I1 input on the AAC20 controller (Freeze Thermostat Status).
4. Activation of the antifreeze thermostat (physical short circuit at the input) triggers the antifreeze protection procedure consisting of stopping the AHU (turning off the fans and closing the dampers), opening the heater valve at output A1 of the AAC20 controller (Heating Valve) to the level specified in HTV_FrostProt_ValveUp (default 100%), and switching on the heater pump at output O3 (Heating Pump Start Command) if configured for use by HPU_Enable (active by default - true).

5. An additional element of antifreeze protection is the use of a return water temperature sensor connected to the U4 input in the AAC20 (Heating Coil Return Water Temperature). If the antifreeze thermostat is triggered, the setpoint for the return water temperature is raised additionally by the level specified in FEZ_RWT_SptUp (by default, 15K).
6. When the temperature of the heater rises and the antifreeze thermostat returns to the normal state, In such case, if there is a sensor for the water temperature at the return from the heater, its setpoint will begin to fall at the rate of FEZ_SetupRamp (default 1K/min) to the normal setpoint (calculated on the basis of the outside temperature); if there is no sensor, the valve closes at the rate of HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current system control.
7. The heater return water temperature sensor also serves as a high limit for the water temperature in the heater by closing the valve if the temperature specified in RWT_MaxSetpoint is too high (85°C by default).
8. If the pump is activated in HPU_Enable (active by default - true) and connected to the O3 output in the AAC20 (Heating Pump Start Command), it is switched on with the delay HPU_OnDelay (by default, 5 s) when the heater valve connected to the A1 output in the AAC20 (Heating Valve) opens to 3% or more, and switched off with the delay specified in HPU_OffDelay (by default, 300 s) when the valve is opened 1% or less.
9. In winter, the pump is permanently activated if the outside temperature falls below the OAT_FrostProtection limit (by default, 6°C) with a central hysteresis of 1K and if the antifreeze thermostat is activated.
10. When using the pump failure signal, which is connected to the I2 input on the AAC20 (Heating Pump Fault), and when the value in HPU_StatusAlarmDelay (by default, 1 s) is set to default, then in the winter period the AHU can be turned off if:
    a. DME_EmergencyStop (deactivated by default - false) is active (set to true),
    b. an alarm is generated on the O2 output of the MIX18 module (Heat Pumps Failure Alarm), and
    c. the pump control output is turned off.
    The alarm is automatically reset if the signal at the input is deactivated and the pump and AHU system resume operation (if stopped).
11. An additional feature to ensure a proper and long-lasting operation of the devices operating the heater is exercising of the pump and valve. First, the pump is exercised, then the valve, which, by default, takes place every Sunday at 1am in case they are not in use. The exercise consists of turning on the pump for the time specified in HPU_Pmp_Vlv_Exercise (120 s by default) and then opening the valve to 100% for the same time as above.

Dampers

1. In winter, when the outside temperature is lower than the limit specified by OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K and the return water temperature sensor is used, then, it must reach the setpoint (calculated from the outside temperature) to allow the dampers to open after the time specified in DME_OnDelay (by default, 300 s).
2. If the return water temperature sensor from the heater is not used, the dampers are opened only after the time specified in DME_OnDelay (by default, 300 s), during which the valve is opened according to the HTV_FrostProt_ValveUp parameter (by default,

100%) and drops at the rate specified by HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current system control.
3. When the outside temperature is above the limit specified in OAT_FrostProtection (by default, 6°C) with a central hysteresis of 1K (summer period), the dampers are opened without the delay specified in DME_OnDelay (by default, 300 s) and the heater return water temperature is not controlled at that time.
4. The dampers connected to the O1 output in the AAC20 (Dampers Start Command) open after the time specified in DME_OnDelay (by default, 300 s) only after the permission from the normally operating heater, and then the signal from the dampers are transmitted as a start permission for the fans with a delay of MAD_RunTime (by default, 150 s)).

Fans

1. If pressure sensors is connected at the U5 and U6 input in the AAC20 (Discharge Air Pressure, Return Air Pressure), each fan in is controlled smoothly connected at the A3 or A4 output in the AAC20 (Discharge Fan Speed Control, Return Fan Speed Control) in the range from FSC_MinSignal (by default, 30%) to FCS_MaxSignal (by default, 100%) so as to maintain the set pressures, or is controlled from the control signal resulting from humidity or manually with a set speed in the above ranges in the absence of connected pressure sensors (the higher control value is selected).
2. Each fan has its preset DischPressSpt pressure (500 Pa by default) and ReturnPressSpt pressure (500 Pa by default), which it is supposed to maintain by adjusting its speed accordingly.
3. Fans connected to the O2 output in the AAC20 (Fans Start Command) start with the delay specified in FSC_OffOnDelay (by default, 5 s) after receiving a permission from the dampers.
4. After receiving the startup permission, the fan speed control signal slowly ramps up at the rate of FSC_Ramp (by default, 1%/min) to the desired value resulting from the corresponding control as indicated above. The rate of rise or fall of the control signal is determined by the same speed.
5. The pressure setpoint behaves similarly, which during the AHU startup ramps up from zero to the desired setpoint at the speed of DSP_PressSptRamp (by default, 50 Pa/min). If it is changed during a normal operation, it will correspondingly start falling or rising at the same speed specified in DSP_PresSptRamp (by default, 50 Pa/min).
6. For a night mode, the set pressure is reduced by multiplying it by the DSP_NightReduce factor (by default, 50%).
7. To protect the fans operation, a fans confirmation signal is connected to the I3 input in the AAC20 (Fans Status/Pressure Switch), which if not activated by the time FDP_BeltAlarmDelay (default 120s), then, an alarm is generated on the O1 output of MIX18 (Fans Failure Alarm) and this causes the AHU to stop. This function can be disabled by setting the zero value in FDP_BeltAlarmDelay (by default, 120 s).
8. In the automatic reset mode specified in FSC_ManualReset (by default, false), after an alarm from the fan, the alarm will be reset and the AHU will resume operation, while after three unsuccessful attempts to start, the system stops and in the automatic mode it can be reset by removing and reactivating the I4 input in AAC20 (Operating Switch), while in the manual reset mode specified in FSC_ManualReset (deactivated - false by default) set to true, after an alarm from the fan the AHU will be stopped and the controller will wait for a reset signal activated by the input connected to the I5 input in MIX18 (Reset) and only then will it attempt to restart the AHU.

Control

1. In winter, during the AHU startup, the temperature control system temporarily raises the setpoint for the discharge temperature by an additional value specified in DAT_SptRamp (by default, 1K) which drops in time specified in DAT_SptDecTime (by default, 600 s).
2. The application allows to configure the TempCtrlMode temperature control function in 3 modes described below.
3. The cascade control function consists of regulating the discharge temperature connected to the U1 input of the AAC20 (Discharge Air Temperature), whose setpoint is determined by the control loop of the return temperature connected to the U2 input of the AAC20 (Return Air Temperature) and the setpoint of the return temperature TempSpt (by default, 22°C) in the heating or cooling function (with the exchanger as the first stage in both cases or without), as well as the fan speed allowing the fans to run above the value derived from RT_DATSpt_shift (by default, 60%), as long as pressure control is not used and the manual setting is lower than that derived from the temperature control function.
4. The fixed-value temperature control function consists of adjusting the discharge air temperature connected at the U1 input of the AAC20 controller (Discharge Air Temperature) based on the set TempSpt temperature (by default, 22°C), and based on the control loop the control level for the heater or cooler and exchanger is calculated.
5. The cascade control function with comfort zone consists of adjusting the discharge air temperature connected at the U1 input of the AAC20 (Discharge Air Temperature) to achieve a set discharge air temperature separate for the heating and cooling functions, taking into account the RT_ComfortZone comfort zone between them (the optimal zone in which heating and cooling are not adjusted – by default, 2°C). The setpoint of supply discharge is the output from the return temperature control system connected to the U2 input of the AAC20 controller (Return Air Temperature) to achieve the set temperature defined by the TempSpt variable (default 22°C). In addition, the discharge air temperature control system can affect the speed of the fans by allowing them to run above the value derived from RT_DATSpt_shift (by default, 60%), unless pressure control is used or the manual speed setting is lower than that derived from the discharge air temperature control function.
6. For the cascade function with comfort zone, the heat or cooling recovery system works in the comfort zone by controlling the exchanger accordingly. When using the economizer function, the control signal can be reversed.
7. The setpoint of discharge temperature is calculated from DAT_LowSetpoint (by default, 14°C) to DAT_HighSetpoint (by default, 26°C).
8. If the discharge air temperature falls below the low limit, the cooler is gradually closed, the heat exchanger begins to work on heat recovery, and the heater begins to open.
9. If the discharge air temperature rises above the high limit, the heater is gradually closed, the heat exchanger begins to work on the recovery of cooling, and the cooler begins to open.
10. The TempSpt set temperature (by default, 22°C) can take into account the winter compensation specified by the WC_DischSptRaise parameter (by default, 4K) or the summer compensation specified by the SC_DischSptRaise parameter (by default, 4K).
11. In the case of a night temperature drop, the RT_ComfortZone comfort zone is expanded four times.

12. In the case of active humidification function, the fan speed can gradually increase with the humidifier control signal, as long as pressure control is not used and the manual setting is lower than the humidification control function.
13. In the case of active dehumidification function using an economizer in mode 2, the fan speed is gradually increased (with attention to the above), and the cooler is opened in turn.
14. When the absolute humidity outside is higher than that of the return, the sequence changes, causing the cooler to open first, and then increase the speed of the fan (with a note as above).
15. In summer, if the outside temperature rises above the OAT_HeaterLimit (by default, 20°C), heater control is blocked, and in winter, if the outside temperature falls below the OAT_CoolerLimit (by default, 14°C), cooler control is blocked.
16. When the antifreeze protection is triggered, all control signals are reset except for the signal for the heater which is set to the level specified in HTV_FrostProt_ValveUp (by default, 100%). When the risk of freezing ceases, all signals return to normal operation.
17. The heater valve is opened or closed by the valve actuator according to the control signal coming from the temperature control system according to the configured TempCtrlMode.

Reheater

1. When HeaterMode (mode 2) is selected as operation mode for both primary and secondary heaters, then when the humidification function is active, only the primary heater works, and when the dehumidification function is in operation, only the secondary heater is used for temperature control.
2. If no humidity control is used (or no active humidification or dehumidification function), both heaters work simultaneously in the temperature control function, but can be configured as needed for gradual operation (the primary heater is the first stage, and the secondary is the second).
3. If the secondary heater pump is activated in HPU_Enable (active by default - true) and connected to the A4 output of the module 4U4A-H or MIX18 (ReHeating Pump Start Command), it is switched on with the delay HPU_OnDelay (by default, 5 s) when the secondary heater valve connected to the A2 output in the module 4U4A-H or MIX18 (ReHeating Valve) opens to 3% or more, and is switched off with the delay specified in HPU_OffDelay (by default, 300 s) when the valve is opened 1% or less.
4. In winter, when the outdoor temperature drops below the OAT_FrostProtection value (by default, 6°C) at the start of the AHU system, the secondary heater valve opens according to the HTV_FrostProt_ValveUp parameter (by default, 100%) and drops at the rate specified by HTV_Ramp (by default, 10%/min) to the normal opening state resulting from the current system control.
5. In winter, the secondary heater pump is permanently activated if the outdoor temperature falls below the OAT_FrostProtection limit (by default, 6°C) with a central hysteresis of 1K.
6. When using the secondary heater pump failure signal which is connected to the U4 input of the module 4U4A-H or the I2 input of the module MIX18 (ReHeating Pump Fault) and when the value in HPU_StatusAlarmDelay (by default, 1 s) is set to default, an alarm is generated on the O2 output of the module MIX18 (Heat Pumps Failure Alarm) and the pump control output is disabled. The alarm is automatically reset if the input signal is deactivated and the pump resumes operation.

7. An additional feature to ensure a proper and long-lasting operation of the devices operating the secondary heater is exercising the pump and valve. First, the pump is exercised, then the valve, which, by default, takes place every Sunday at 1am in case they are not in use. The exercise consists of turning on the pump for the time specified in HPU_Pmp_Vlv_Exercise (120 s by default) and then opening the valve to 100% for the same time as above.

Cooler

1. When cooling is needed, the cooler valve connected to the A2 output (Cooling Valve) opens based on a stronger signal coming from the temperature control system or dehumidification function.
2. The control of the cooler valve is blocked below the OAT_CoolerLowLimit temperature (by default, 14°C) with a central hysteresis of 1K.
3. It is possible to block the control of the cooler valve in the humidification function with the CCV_CoolOnHumDisable parameter (active by default – true).
4. During the AHU startup and each time the valve is opened from zero, the control signal gradually increases at the rate specified in CCV_VlvRamp (by default, 5%/min).
5. To protect against too low air temperature behind the cooler, it is possible to use a temperature sensor connected to the U3 input on the MIX18 module (Cooling Limit Air Temperature) causing the cooler valve to gradually close when the temperature drops to the LIM_Setpoint value (by default, 14°C).
6. An additional feature to ensure a proper and long-lasting operation of the cooler is exercising the valve. It is carried out by default every Sunday at 1am in case it is not being used. Exercise consists of opening the valve to 100% for the time specified in CCV_Vlv_Exercise (120 s by default).

Exchanger

1. In order to increase energy efficiency, the AHU system is additionally equipped with an exchanger to recover thermal energy (heat or cold) from either return or outside air in order to use this energy to heat or cool the incoming outside air.
2. One of five types of exchanger can be selected in EnergyRecovMode. Type 4 indicates a twin-coil exchanger with a pump on a return, and type 5 means a twin-coil exchanger with a pump on a supply.
3. When the AHU system is started, the permission to switch on an exchanger pump connected to the O4 output in the AAC20 controller (TwinCoil Pump Start Command) starts with the delay specified in ERP_OnDelay (by default, 5 s).
4. The exchanger is controlled at the A5 output of the AAC20 (TwinCoil Exchanger Valve) controller primarily from the temperature control system, but its control is also affected by the economizer function, humidity control.
5. To protect the exchanger from frosting, a signal connected to the U7 input of the AAC20 (TwinCoil Exchanger Pressure Switch) is used to disable the exchanger's pump control and the control signal is set to zero.
6. In addition, in the case of using a temperature sensor connected at the U4 input of the MIX18 module (Medium Air Temperature) located on the piping installation of the exchanger, the opening of the exchanger valve can be controlled in type 4 by decreasing its control when the outside temperature decreases, and in type 5 by increasing its control when the outside temperature decreases, which serves to protect the exchanger's fluid against frosting.

7. If the exchanger control signal is equal to or greater than 3% the exchanger pump will be switched on.
8. If the exchanger control signal is equal to or less than 1% after the ERP_OffDelay (by default, 300 s), the exchanger pump will be turned off.
9. The exchanger pump can be switched on permanently during normal operation of the AHU system if the outside temperature falls below OAT_FrostProtection (by default, 6°C).
10. When using the exchanger pump failure signal which is connected to the I4 input on the MIX18 module (TwinCoil Pump Fault) and when the value in ERP_StatusAlarmDelay (by default, 1 s) is set to default, an alarm is generated on the O3 output of the MIX18 module (TwinCoil Pump Failure Alarm), the exchanger control is reset, and the exchanger pump is deactivated. The alarm is automatically reset if the input signal is deactivated and the exchanger resumes operation.
11. An additional feature to ensure a proper and long-lasting operation of the devices operating the exchanger is exercising of the pump and valve. First, the pump is exercised, then the valve, which, by default, takes place every Sunday at 1am in case they are not in use. The exercise consists of turning on the pump for the time specified in ERP_Pmp_Vlv_Exercise (120 s by default) and then opening the valve to 100% for the same time as above.

Economizer

1. In addition, an economizer function is used to support energy efficiency, the mode of which can be set in EconomizerMode.
2. Economizer in operation mode 1 compares only the outdoor and return temperatures to determine the optimal signal for energy recovery by the exchanger.
3. In mode 2, the economizer determines the energy recovery function based on measurements of outdoor and return temperatures and humidity, deciding in the summer using the calculated enthalpy and absolute humidity which air flow to use for cooling (return or fresh).
4. Calculations based on absolute humidity apply only when using the dehumidification function.
5. Both functions, enthalpy and absolute humidity, are triggered when the appropriate conditions are met taking into account the central hysteresis of EnthalpyDiff (by default, 5kJ/kg) and AbsHumDiff (by default, 1g/kg) respectively, with a delay specified by SwitchoverDel (by default, 300s).

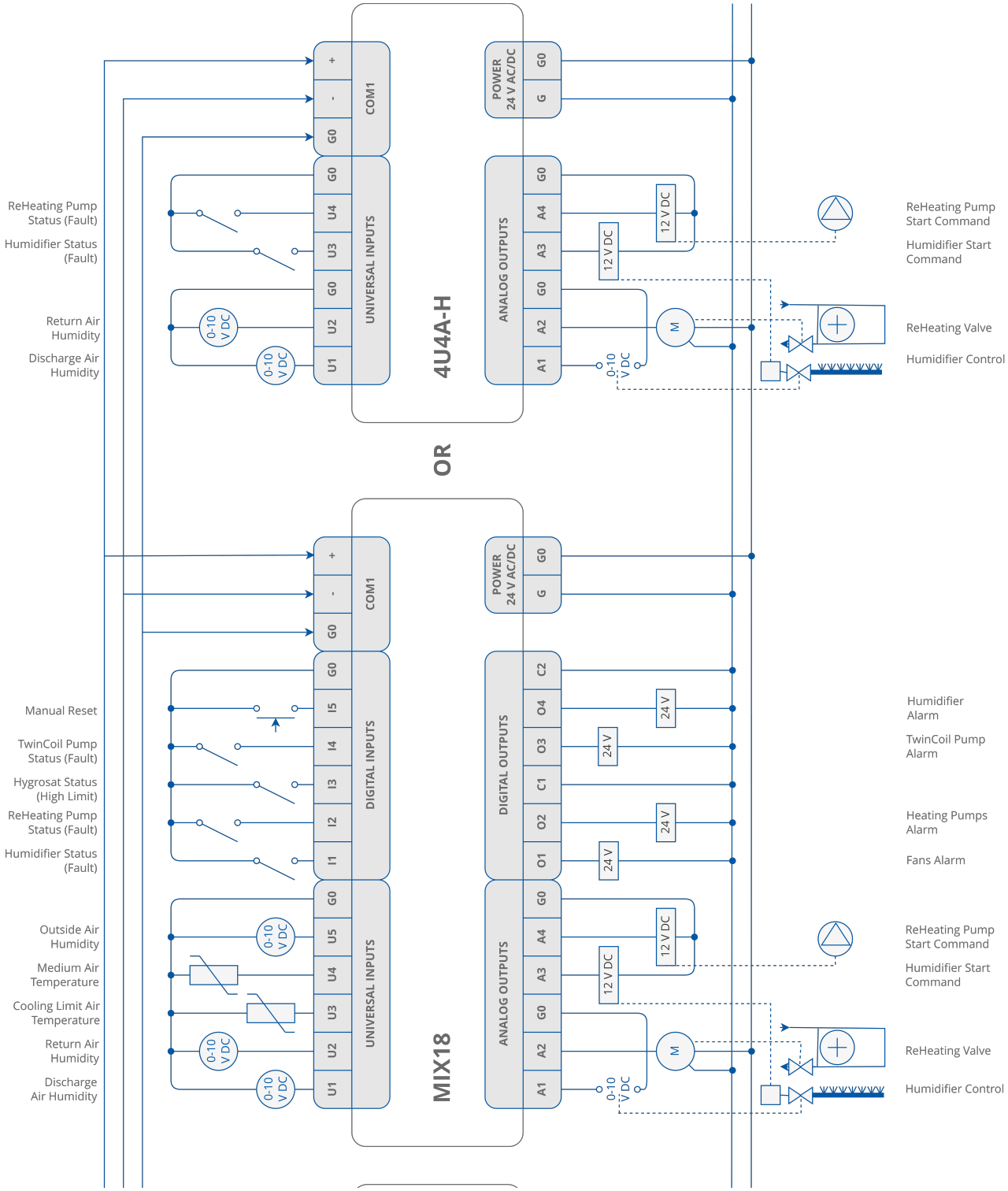
Humidifier

1. The AHU is also equipped with a humidification and dehumidification function. The humidification function is started with a delay of HUM_FanOnDelay (by default, 300 s) after confirming the operation of the fans connected to the I3 input in the AAC20 (Fans Status/Pressure Switch).
2. In case of lack of confirmation that the fans connected to the I3 input of the AAC20 (Fans Status/Pressure Switch) is operating, the humidification function is turned off immediately.
3. The humidification function is active when the outdoor temperature is lower than the OAT_HighHum parameter (by default, 14°C), and the dehumidification function is active when the outdoor temperature is higher than the OAT_LowDeh parameter (by default, 15°C).

4. To implement humidity control, a discharge air sensor connected to the U1 input of the 4U4A-H or MIX18 (Discharge Air Humidity) module and an return air sensor connected to the U2 input of the 4U4A-H or MIX 18 (Return Air Humidity) module are required, depending on the selected humidity control function.
5. The application allows to configure the HumCtrlMode humidity control function in 4 modes described below.
6. The function of return relative humidity control with comfort zone (optimal zone in which humidification and dehumidification control does not take place) is to regulate humidity so as to achieve HumSpt as the setpoint for return (by default, 55%) taking into account the comfort zone HUMDEH_ComfZone (by default, 4%) using humidification or dehumidification function. The comfort zone is quadrupled in the case of night temperature drop.
7. The function of controlling the return relative humidity without comfort zone is to adjust the humidity to achieve the HumSpt as the setpoint for the return (by default, 55%) using the humidification or dehumidification function.
8. The function of the discharge absolute humidity control is to adjust the humidity so as to achieve the discharge setpoint determined by the value from the return humidity sensor. The discharge humidity setpoint is calculated by the control loop, which is then used to regulate the discharge humidity using humidification or dehumidification functions. An absolute (not relative) humidity sensor connected on the discharge air is required to perform this function.
9. The function of the fixed-value absolute humidity discharge control is to adjust the humidity so as to achieve the HumSpt as the discharge setpoint (by default, 55%) using the humidification or dehumidification function. An absolute (not relative) humidity sensor connected on the discharge air is required to perform this function.
10. The humidity control function has two independent control loops, one for humidification control directly controlling the humidifier connected to the A1 output of the AAC20 controller (Humidifier Control Signal), and the other for dehumidification control affecting the control of the cooler connected to the A2 output of the AAC20 controller (Cooling Valve). The maintenance of the previously reduced temperature to the set level according to the temperature control is done by controlling the secondary heater connected to the A2 output of the 4U4A-H or MIX18 module (ReHeating Valve).
11. Both humidification and dehumidification control functions ramp up gradually at the speed of HUM_RampUp (by default, 10%/min) and DEH_RampUp (by default, 10%/min), respectively.
12. The HumSpt set humidity (by default, 55%) can take into account either winter compensation determined by a linear function in relation to the outside temperature from RAH_MinHumSpt (by default, 30%Rh) to HumSpt (by default, 55%) or summer compensation determined by a linear function in relation to the outside temperature from HumSpt (by default, 55%) to RAH_MaxHumSpt (by default, 60%Rh).
13. Depending on the type of humidifier selected in HumidifierMode, the A3 output control in the 4U4A-H or MIX18 module (Humidifier Start Command) is activated as required: as a water humidifier pump (mode 1) or as switched on permanently (if there is no failure) during AHU operation as a steam humidifier enabler (mode 2).
14. In case of a humidifier failure activated at the U3 input of the 4U4A-H module or at the I1 input of the MIX18 module (Humidifier Fault), the humidifier control is turned off, the water humidifier pump/steam humidifier is shut down, and an alarm is generated at the O4 output of the MIX18 module (Humidifier Failure Alarm).

15. In addition to the hygrostat connected to the I3 input of the MIX 18 module (Hygrostat), which, when activated, turns off the humidification function (turns off the humidifier and pump / permit control), there is also a function to protect the occurrence of too much discharge humidity (to prevent the ducts from getting wet). If the discharge air humidity begins to increase towards the DAH_MaxSpt value (by default, 90%), then the humidifier control gradually decreases to zero.
16. Deactivation of the humidistat or humidifier failure automatically resets the alarm and returns to normal control mode.

8.8.3 Electrical Connections



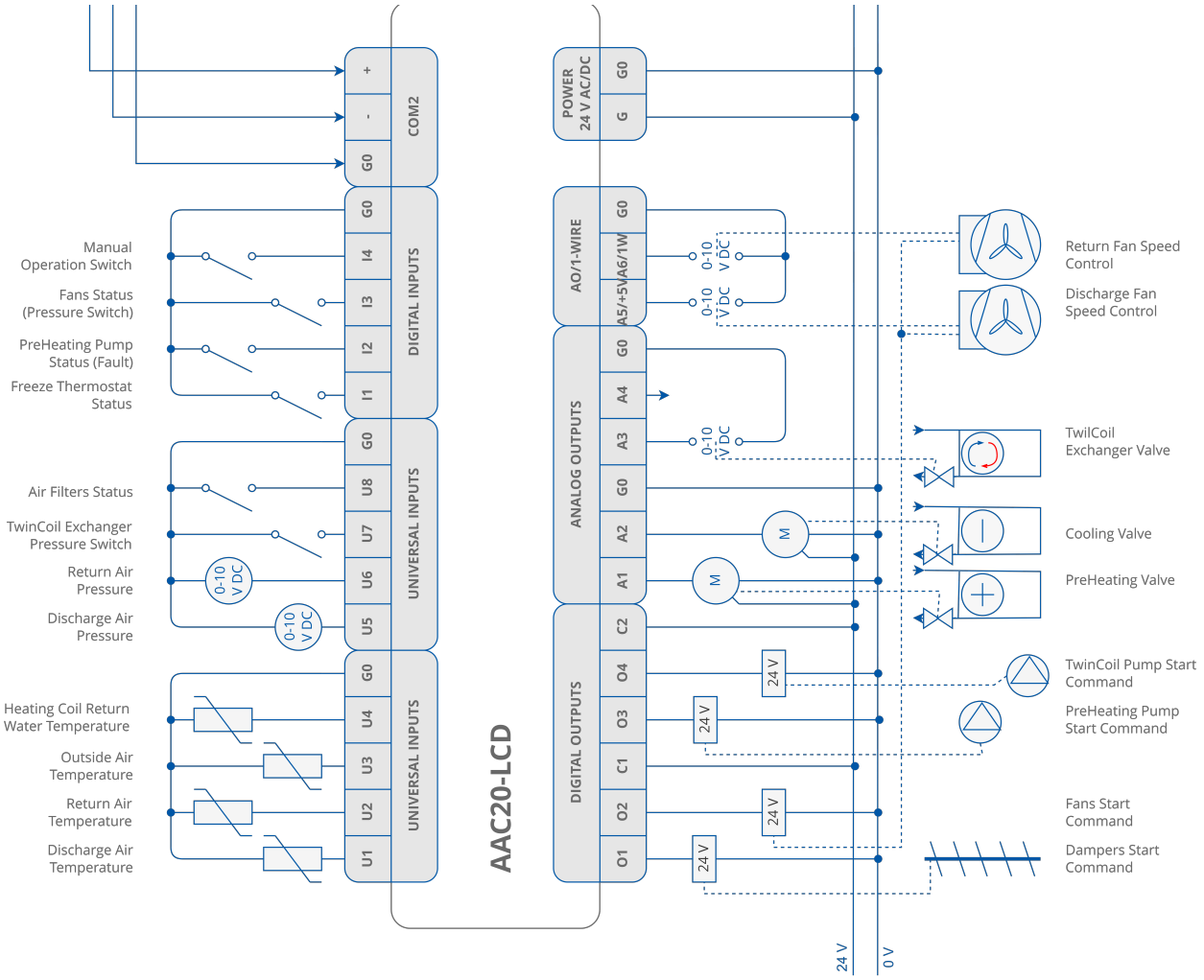


Figure 96. Electrical connections for supply and exhaust air handling unit with twin-coil exchanger, water heaters and water cooler, with humidification and dehumidification function

9 Network Variables

Name	Units	Access	Modbus Address	BACnet Object	Default Value	Description
DischargeTemp	°C	RO	1000	AV0	N/a	Discharge Air Temperature sensor reading
ReturnTemp	°C	RO	1002	AV1	N/a	Return Air Temperature sensor reading
OutsideTemp	°C	RO	1004	AV2	N/a	Outside Air Temperature sensor reading
ReturnWTemp	°C	RO	1006	AV3	N/a	Return Water Temperature sensor reading
DischargePress	Pa	RO	1008	AV4	N/a	Discharge Air Pressure sensor reading
ReturnPress	Pa	RO	1010	AV5	N/a	Return Air Pressure sensor reading
CO2	ppm	RO	1012	AV6	N/a	CO2 concentration sensor reading
DischargeHum	%RH	RO	1014	AV7	N/a	Discharge Air Humidity sensor reading
ReturnHum	%RH	RO	1016	AV8	N/a	Return Air Humidity sensor reading
CoolLimTemp	°C	RO	1018	AV9	N/a	Cooling Limit air temperature sensor reading
MedMixExTemp	°C	RO	1020	AV10	N/a	Medium, Mixing or Exhaust Temperature sensor reading
OutsideHum	%RH	RO	1022	AV11	N/a	Outside Air Humidity sensor reading
PlantMode	N/a	RO	1038	MV0	N/a	Plant Mode reading set according to schedule event Modbus: 0 – Off; 2 – Night cycle BACnet: 1 - Off; 3 - Night cycle; 5 - Occupied period

Name	Units	Access	Modbus Address	BACnet Object	Default Value	Description
						4 – Occupied period
ERdiffPressure	N/a	RO	2000:0	BV0	N/a	Differential pressure switch on the exchanger status reading
Filters	N/a	RO	2000:1	BV1	N/a	Differential pressure switch on the filters - common status reading
Thermostat	N/a	RO	2000:2	BV2	N/a	(Pre)Heater freeze thermostat status reading
PreHPumpStatus	N/a	RO	2000:3	BV3	N/a	(Pre)Heater pump status reading
FanDiffPressure	N/a	RO	2000:4	BV4	N/a	Differential pressure switch on the fans -common status reading
OperationSwitch	N/a	RO	2000:5	BV5	N/a	Manual operation switch status reading
HumidifierStatus	N/a	RO	2000:6	BV6	N/a	Humidifier status reading
ReHPumpStatus	N/a	RO	2000:7	BV7	N/a	ReHeater pump status reading
Hygrostat	N/a	RO	2000:8	BV8	N/a	High Limit Hygrostat status reading
ERStatus	N/a	RO	2000:9	BV9	N/a	Exchanger status reading
Reset	N/a	RO	2001:15	BV21	N/a	Manual reset input reading (for MIX18 only)
DischargeFanControl	%	RO	1024	AV12	N/a	Discharge Fan Control output reading
ReturnFanControl	%	RO	1026	AV13	N/a	Return Fan Control output reading
ERControl	%	RO	1028	AV14	N/a	Exchanger Control output reading
PreHeatValve	%	RO	1030	AV15	N/a	(Pre)Heater Valve actuator output reading
CoolValve	%	RO	1032	AV16	N/a	Cooler Valve actuator output reading

Name	Units	Access	Modbus Address	BACnet Object	Default Value	Description
ReHeatValve	%	RO	1034	AV17	N/a	ReHeater Valve actuator output reading
HumidifierControl	%	RO	1036	AV18	N/a	Humidifier Control output reading
DampersCommand	N/a	RO	2000:10	BV10	N/a	Dampers Command output state reading
FansCommand	N/a	RO	2000:11	BV11	N/a	Fans Command output state reading
PreHeatPump	N/a	RO	2000:12	BV12	N/a	(Pre)Heater Pump Command output state reading
ERCommand	N/a	RO	2000:13	BV13	N/a	Exchanger Command output state reading
HumidifierCommand	N/a	RO	2000:14	BV14	N/a	Humidifier Command output state reading
ReHeatPump	N/a	RO	2000:15	BV15	N/a	ReHeater Pump Command output state reading
FanFailureAlarm	N/a	RO	2001:0	BV16	N/a	Fan Failure Alarm state reading
PreHeatPumpAlarm	N/a	RO	2001:1	BV17	N/a	(Pre)Heater Pump Failure Alarm state reading
ReHeatPumpAlarm	N/a	RO	2001:2	BV18	N/a	ReHeater Pump Failure Alarm state reading
ERFailureAlarm	N/a	RO	2001:3	BV19	N/a	Exchanger Failure Alarm state reading
HumidifierFailureAlarm	N/a	RO	2001:4	BV20	N/a	Humidifier Failure Alarm state reading
TempSetpoint	°C	RW	1100	AV19	22	Room/Return Temperature setpoint
HumiditySetpoint	%RH	RW	1102	AV20	55	Room/Return Humidity setpoint
CO2Setpoint	ppm	RW	1104	AV21	600	Room/Return CO2 concentration setpoint

Name	Units	Access	Modbus Address	BACnet Object	Default Value	Description
DischargePressureSpt	Pa	RW	1106	AV22	500	Discharge Fan Differential Pressure setpoint
DischargePressureSpt	Pa	RW	1108	AV23	500	Return Fan Differential Pressure setpoint
HeaterMode	N/a	RW	1200	AV24	2	Heater operating mode settings 1 – Water PreHeater as single Water Heater 2 – Water PreHeater & Water ReHeater use
EnergyRecovMode	N/a	RW	1202	AV25	1	Exchanger operating mode settings 0 – no exchanger 1 – Wheel exchanger 2 – CrossFlow exchanger 3 – Mixing Dampers as exchanger 4 – TwinCoil with Pump on Return 5 – TwinCoil with Pump on Discharge
CoolerMode	N/a	RW	1204	AV26	1	Cooler operating mode settings 0 – no cooler 1 – Water Cooler
HumidifierMode	N/a	RW	1206	AV27	1	Humidifier operating mode settings 0 – no humidifier 1 – Water humidifier 2 – Steam humidifier
EconomizerMode	N/a	RW	1208	AV28	1	Economizer operating mode settings 0 – no economizer function use 1 – Economizer function based on Return Air Temperature 2 – Economizer function based on Enthalpy
TempCtrlMode	N/a	RW	1210	AV29	1	Temperature control mode settings 1 – Cascade Temperature control 2 – Constant Discharge Temperature control 3 – Comfort Zone Temperature control
HumCtrlMode	N/a	RW	1212	AV30	1	Humidity control mode settings 1 – Comfort Humidity control 2 – Return Humidity control 3 – Discharge Absolute Humidity control 4 – Constant Discharge Absolute Humidity control

Name	Units	Access	Modbus Address	BACnet Object	Default Value	Description
CO2Range	ppm	RW	1214	AV31	2000	CO2 concentration transmitter range
DisPressRange	Pa	RW	1216	AV32	1000	Discharge Differential Pressure transducer range
RetPressRange	Pa	RW	1218	AV33	1000	Return Differential Pressure transducer range
PlantSchedule	-	RW	1500	SCH0	N/a	AHU Plant Schedule

Table 23. Network variables

10 Disclaimer

10.1 Applied to: Universal AHU Application

Universal AHU Application is an example application allowing one to familiarize with the capabilities of the controller manufactured by iSMA CONTROLLI S.p.A.:

- iSMA-B-AAC20,
- iSMA-B-AAC20-LCD,
- iSMA-B-AAC20-M,
- iSMA-B-AAC20-LCD-M,
- iSMA-B-AAC20-D,
- iSMA-B-AAC20-LCD-D.

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