Ventwork

SOFTWARE FOR VENTILATION UNITS

VERSION 1.1

TABLE OF CONTENTS

1. ABOUT VENTWORK

Ventwork is a software created for controllers of ventilation units. Controller with Ventwork can control ventilation units equipped with a rotor heat exchanger or a plate heat exchanger with a bypass valve. The system may operate without a heat exchanger (air supply chamber). Controller may also be used for control of an electrical or water heater, electrical pre-heater, ventilator with EC or AC type motors, water or Freon chiller. The controller may be operated via a control panel or modbus RTU protocol.

2. VENTILATION CONTROLLER

2.1. TEMPERATURE CONTROL

Temperature may be controlled by the following ventilation modes:

1. Maintaining the supply air temperature (Supply):
2. Maintaining the exhaust (room) air temperature (Room).
3. Adjusting the maintained air temperature according to the outdoor temperature by changing the supplied or exhausted air volume (Outdoor).

	Mode		
Ventilation mode	*Supply*	*Room*	*Outdoor*

To maintain the desired temperature a *Temperature setpoint* parameter is used.

	Min(°C)	**Max(°C)**
Temperature setpoint	15	30

The controller has three ventilation sequences:

1. *Heating* sequence
2. Heat exchanger (E*xchange*) sequence.
3. *Cooling* sequence.

Every sequence (*Heating*, *Exchange* and *Cooling)* has assigned PI regulators with configurable *Kp (proportional)* and *Ki* (integrated) coefficients

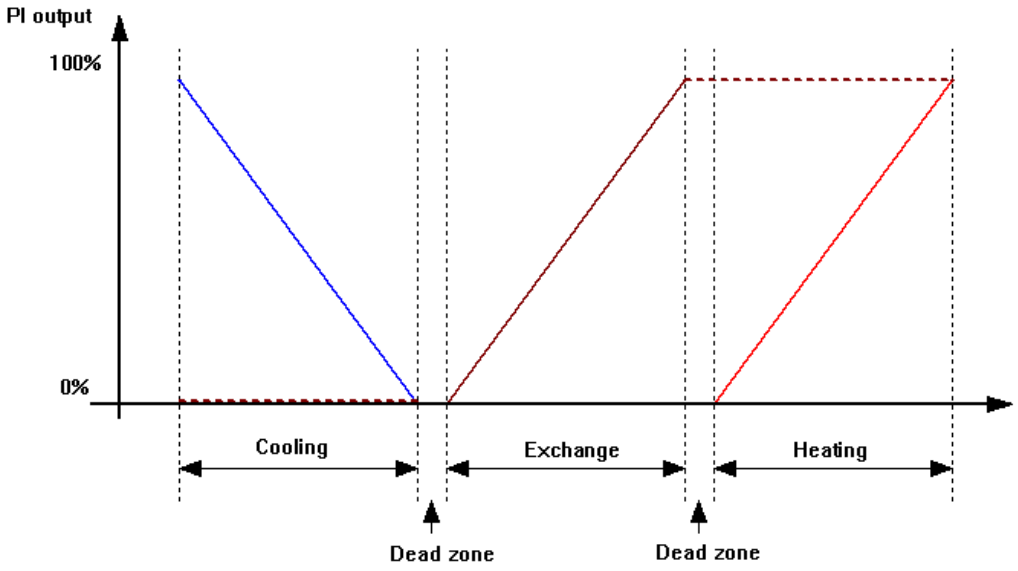
Settings of PI coefficients:

	Min	**Max**
Heater Kp	0.1	100
Heater Ki	0.001	10
Exchanger Kp	0.1	100
Exchanger Ki	0.001	10
Chiller Kp	0.1	100
Chiller Ki	0.001	10

Sequences may be switched off. For example, when heating is not necessary, a heating sequence is disconnected by selecting *No heater* under the heater type in *Heating*. The system can operate without a heat exchanger (as an air supply chamber) by switching the *Exchange* sequence off (*No exchanger*). After switching off the *Exchange* sequence, the unit operates without a heat exchanger and only temperature control by supply air (*Ventilation mode*) is possible. To switch off cooling, select *No chiller* under the *Chiller* settings and the *Cooling* sequence will be disconnected.

2.2. MAINTAINING THE SUPPLY AIR TEMPERATURE

Each sequence (*Heating*, *Exchange* and *Cooling)* used in this algorithm maintains a desired supply air temperature using a supply air sensor. Sequences are executed consistently. When the system operates in the *Exchange* sequence, the heat exchanger is controlled according to PI regulator of the *Exchange* sequence. Heating sequence is turned on when the *Exchange* sequence reaches 100%, whereas, *Cooling* sequence is turned on when the *Exchange* sequence reaches 0%. The system starts at 0% in the *Exchange* sequence and continues to operate at the desired temperature. If the system is equipped with a water heater, the unit starts at 75% in the *Heating* sequence and continues to operate according to temperature demand.



Neutral zone (dead zone) may be used to maintain a desired temperature with a *Tset dead zone* parameter. For example, if the set desired temperature is 22°C and *Tset dead zone* is set to 2°C, then the desired temperature for heating is 21°C, and for cooling - 22°C.

	Min(°C)	Max(°C)
Tset dead zone	0	6

Delay *PI dead time* may be set for transition between sequences. When conditions to move from one sequence to another are suitable, the set delay time is started. For example, when the heat exchanger sequence reaches 100%, the controller will switch to the heating sequence only after the set *PI dead time*. The same applies when resuming from the heating sequence to the heat exchanger sequence.

	Min (seconds)	Max (seconds)
PI dead time	0	1800

Transition to the heating sequence is only possible when the outdoor temperature is lower than the set *Allow heat when TOUT bellow* temperature.

Transition to the cooling sequence is only possible when the outdoor temperature is higher than the set *Allow cool when TOUT above* temperature.

	Min(°C)	Max(°C)
Allow heat when TOUT bellow	20	40
Allow cool when TOUT above	10	30

2.3. MAINTAINING THE EXHAUST (ROOM) AIR TEMPERATURE

This ventilation mode is only available when the system is equipped with a heat exchanger. This algorithm has an additional PI regulator (*Room PI*) that adjusts the supply air according to the exhaust air sensor to maintain a desired room temperature.

Settings of Room PI coefficients:

	Min	Max
Room Kp	0.1	100
Room Ki	0.001	10

Supply air limits for the regulator:

	Min(°C)	Max(°C)
Min supply air temp	15	25
Max supply air temp	24	40

Supply air temperature during the cooling sequence may as well be even lower. For this, select *Min supply air at cooling*.

	Min(°C)	Max(°C)
Min supply air at cooling	0	15

In order to avoid supply of excessively cold air, a function *Min cooling air detection* shall be used. This function switches off the cooling unit when the supply air temperature drops below the set *Min supply air at cooling* temperature. This function may be deactivated.

Min cooling air detection	Enable	Disable

2.4. BY OUTDOOR TEMPERATURE

Depending on the outdoor temperature, this ventilation mode may operate as a mode for maintaining supply air temperature or as a mode for maintaining exhaust air temperature. Outdoor temperature value for switching between modes is set under a setting *OutdoorDepend*. If the outdoor temperature is below the set value, the mode operates as a mode for maintaining supply air temperature. If the outdoor temperature exceeds the set value, the mode operates as a mode for maintaining room air temperature.

	Min(°C)	**Max(°C)**
Outdoor depend	10	30

3. FAN CONTROLLER

Fan controller can control 2 types of fans *(Fans type):* with EC or AC motors.

	Type	
Fans type	EC	AC

Fan speed is set by a speed index (*Fans speed)*. Available fan speeds: *low, middle, high or stop:*

	Index			
Fans speed	Low	Middle	High	Stop

3.1. CONTROL OF EC FANS

The system may control two EC type fans - supply air (SAF) and exhaust air (EAF). Both fans have separate working modes and settings.

Available working modes of SAF fan:

1. By percentage
2. By pressure
3. By flow (m3/h)

Available working modes of EAF fan:

1. By percentage
2. By pressure
3. By flow
4. By percentage of SAF

Each fan (SAF, EAF) is controlled by a separate 0-10V control voltage (*SAF 010 AO Pin, EAF 010 AO Pin*) and power relay (*Fans DO 1 (SAF) Pin*, *Fans DO 2 (EAF) Pin*). Power relay is switched on when the control voltage exceeds 2V and switched off when the voltage drops below 2V.

	Mode			
SAF mode	Percents	Pressure	Flow	
EAF mode	Percents	Pressure	Flow	SAF + %

3.1.1 Control of EC fans by percent

In the fan working mode by percent, percents proportionally correspond to the output voltage, e.g., 2V corresponds to 20 % motor capacity, 5V – 50 %, etc. The lowest possible value - 20%;

maximum value - 100 %. Different speeds (low, middle, high) cannot be set to the same value. The maximum speed value must always be greater than the average speed value, and the average speed value must be higher than the minimum speed value.

	Min (%)	**Max (%)**
SAF low by percents	20	(SAF midd by percents) -1
SAF midd by percents	(SAF low by percents) +1	(SAF high by percents) -1
SAF high by percents	(SAF midd by percents) +1	100
EAF low by percents	20	(EAF midd by percents) -1
EAF midd by percents	(EAF low by percents) +1	(EAF high by percents) -1
EAF high by percents	(EAF midd by percents) +1	100

3.1.2 EC fan control by pressure

Pressure transducer is required for fan operation by pressure. Fan adjusts PI regulators according to the set desired pressure (low, middle, high) and values of the pressure transducer.

After connecting the pressure transducer, pressure values shall be set for 0V and 10V voltages.

	Min(Pa)	**Max(Pa)**
Transmitter Psi by 0V	0	10000
Transmitter Psi by 10V	0	10000

Pressure settings:

	Min (Pa)	**Max (Pa)**
SAF low by transmitter	0	SAF midd by transmitter
SAF midd by transmitter	SAF low by transmitter	SAF high by transmitter
SAF high by transmitter	SAF midd by transmitter	10000
EAF low by transmitter	0	EAF midd by transmitter
EAF midd by transmitter	EAF low by transmitter	EAF high by transmitter
EAF high by transmitter	EAF midd by transmitter	10000

3.1.3 EC fan control by flow

Air flow transducer is required for fan operation by flow. Fan adjusts PI regulators according to the set desired flow (*low, middle, high*) and values of the flow transducer.

After connecting the flow transducer, flow values shall be set for 0V and 10V voltages.

	Min(Pa)	**Max(Pa)**
Transmitter Psi by 0V	0	10000
Transmitter Psi by 10V	0	10000

Flow settings:

	Min (m^3/h)	**Max (m^3/h)**
SAF low by transmitter	0	SAF midd by transmitter
SAF midd by transmitter	SAF low by transmitter	SAF high by transmitter
SAF high by transmitter	SAF midd by transmitter	10000
EAF low by transmitter	0	EAF midd by transmitter
EAF midd by transmitter	EAF low by transmitter	EAF high by transmitter
EAF high by transmitter	EAF midd by transmitter	10000

Fan settings:

	Min	**Max**
SAF K factor	0.1	1000
SAF X factor	0.001	0.001
EAF K factor	0.1	1000
EAF X factor	0.001	0.001

3.1.4 EC supply air fan control by the exhaust air fan

In this mode the speed of EAF fan is adjusted according to the current SAF fan speed by adding the set EAF fan speed in percents.

	Min (%)	**Max (%)**
EAF from SAF low speed	-100	100
EAF from SAF midd speed	-100	100
EAF from SAF high speed	-100	100

3.2. CONTROL OF AC FANS

For AC fan control by a fan speed index (*Fans speed*) a relevant output is activated. Outputs for control of AC fans:

- *Fans DO 1 (SAF) Pin* (low speed)
- *Fans DO 2 (EAF) Pin* (middle speed)
- *Fans DO 3 Pin* (high speed)
- *Fans DO 4 Pin* (slowing down)

3.3. FAN BOOST FUNCTION

BOOST function starts the fans at a certain speed. BOOST function can be deactivated in two ways:

- *Set BOOST* command
- External *Fans Boost DI Pin* contact

Function has a timer - *Fans boost time.* If a function timer is set for more than 0 min, then, after activating the Boost function, it will operate for the time set in the timer and then will switch off. If the BOOST function is activated via an external contact, the function timer will start counting only when the external contact becomes inactive. If the contact is on, the timer won't start. The timer is turned off when the function timer is set for 0 min. Then the function is turned on by one click and turned off by the other. If the BOOST function is turned on via *Set BOOST* command, *Boost* will remain on until a shutdown command is received. If he BOOST function is started via an external contact, the function will remain on for as long as the external contact is on. When the contact is off, the function will turn off too.

	Min (seconds)	**Max (seconds)**
Fans boost time	0	240

Fan BOOST speed for control by percents:

	Min (%)	**Max (%)**
SAF boost by percents	SAF low by percents +1	100
EAF boost by percents	EAF low by percents +1	100

Fan BOOST speed for control by pressure:

	Min (Pa)	**Max (Pa)**
SAF boost by transmitter	SAF low by transmitter	Transmitter Psi by 10V
EAF boost by transmitter	EAF low by transmitter	Transmitter Psi by 10V

Fan BOOST speed for control by transmitter:

	Min (m^3/h)	**Max (m^3/h)**
SAF boost by transmitter	SAF low by transmitter	Transmitter Psi by 10V
EAF boost by transmitter	EAF low by transmitter	Transmitter Psi by 10V

3.4. FAN CONTROL PRIORITIES

Fan can control various system functions such as maintaining of humidity, CO^2 removal, etc. Conditions when several functions with different fan speeds are activated at the same are possible.

In that case the speed is set according to a function priority. The speed is decided by a function with the highest priority level.

Priorities from the highest level:

1. FP_SYSTEM (system crashes)
2. FP_ANTIFROST (heat exchanger anti-frost function)
3. FP_REMOVE_RH_CO2 (humidity removal, CO^2 removal)
4. FP_KEEP_RH (humidity maintenance)
5. FP_BOOST (fan BOOST function)
6. FP_NIGHTCOOL (night cooling)
7. FP_MODBUS (speed by index: low, middle, high, stop)

3.5. STARTING AND STOPPING OF THE FANS, CONTROL OF AIR SUPPLY VALVES

The fans start in SM_NORMAL mode after the set *System starting time*. The start-up mode SM_STARTING counts down the set *System starting time* and opens the air supply valves.

	Min (seconds)	**Max (seconds)**
System starting time	0	600

Air Damper DO Pin output is used for control of air supply valves. Valves are opened before the start-up of fans (*Air Damper DO Pin* output is activated) and are closed when the fans stop (*Air Damper DO Pin* output is deactivated).

In a ventilation system equipped with an electrical heater, blowdown is performed during shutdown of the fans. There is no delay if the system is equipped with a water heater. Time for purging of fans is set under the *Fans blowdown time* setting.

	Min (seconds)	**Max (seconds)**
Fans blowdown time	0	240

4. HEATER CONTROLLER

The following types of heaters are available:

1. Electrical on/off (El.On/Off);
2. Electrical 0-10 V (El.0-10V);
3. Electrical PWM (El.Pulser);
4. Water with a 3-way valve (Water 3 pos.);
5. Water 0-10 V. (Water 0-10V);
6. Water heating-cooling (HC 0-10V);

4.1. ELECTRICAL HEATER ON/OFF

This algorithm controls the electric heater via a single relay output (*Heater DO Pin)*. Heating period - 60 seconds. Need for heating is estimated at the beginning of each period. Dependence of the starting time on the need for heating:

60 s – 100 %

45 s – 75 %

30 s – 50 %

15 s – 25 %

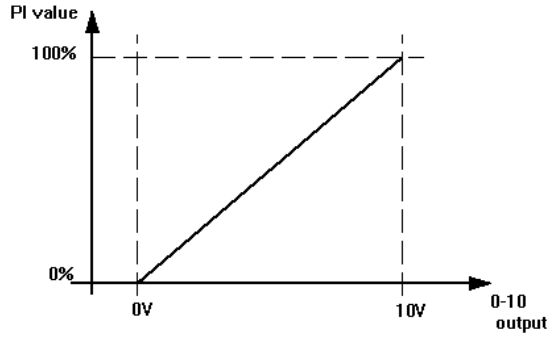
0 s – 0 %

If the need for heating is equal to 100%, a relay will be switched on for the entire period. If the need for heating is equal to 50%, a relay will be on for 30 seconds, and off for 30 seconds.

4.2. ELECTRICAL HEATER 0-10V

This algorithm controls the electric heater via 0-10V DC signal (*Heater 010 AO Pin) and relay (Heater DO Pin).*

Dependency of the 0-10V signal on the need for heating:



Relay is switched on upon demand for heating and switched off after 10 minutes when there is no need for heating.

4.3. ELECTRICAL HEATER PWM

This algorithm controls an electric heater via a PWM signal. PWM signal (*Heater 010 AO Pin)* and relay (*Heater DO Pin) are used for controlling the unit.*

High level of the PWM signal output - 6V, low level - 0V. Signal period - 10s.

Dependence of the PWM signal start on the need for heating.

10 s – 100 %

7.5 s – 75 %

5 s – 50 %

2.5 s – 25 %

0 s – 0 %

Relay is switched on upon demand for heating and switched off after 10 minutes, when there is no need for heating.

4.4. ELECTRICAL HEATER PROTECTION AGAINST OVERHEATING

In case of an electric heater, a function against overheating is activated. Function uses a *Overheat DI Pin* input. Two types of overheat detection are possible based on the *Overheat detection* setting:

1. Close/open contact: protection is activated when the *Overheat DI Pin* is triggered.

2. Based on the contactor state: when heating is off the input shall be off as well and vice versa. Otherwise, an overheat protection is triggered.

Overheat detection	Dry contact	If contactor works

When the overheat protection is triggered, the system switches to an emergency mode, the unit is stopped. If a setting *Full fans speed at overheat* is active, fans are started at the highest speed, if not - purging of the fans (*Fans blowdown time)* is performed and the unit is stopped.

4.5. WATER HEATER WITH A 3-WAY VALVE

Heat Valve Up DO Pin and *Heat Valve Down DO Pin* outputs are used for control of a three-way valve. Depending on whether the need for heating increases or decreases, a control signal is activated either to open the valve (*Heat Valve Up DO Pin*) or to close it (*Heat Valve Down DO Pin*). Valve opening period - 150 s. After opening the valve to the extent needed, the signal turns off. Later this signal is activated on demand to close or open the valve. When the need for heating is 0%, *Heat Valve Down DO Pin* output is active over the entire period. When the need for heating is 100%, *Heat Valve Up DO Pin* output is active over the entire period.

Example:

When the need for heating is 50 %, the control signal will be on for 75 sec. Then it will be switched off. When the need for heating drops to 49 %, a signal for closing the valve for 1.5 sec. is triggered and so on.

4.6. WATER HEATER 0-10V

This algorithm controls the water heater valve drive via 0-10 V DC signal (*Heater 010 AO Pin)*. Principle of operation is the same as for electrical 0-10 V, except a relay output (*Heater DO Pin)* is used for the circulation pump control instead.

4.7. WATER HEATING-COOLING 0-10V

This algorithm controls a 3-way valve via the same 0-10 V output (*Heater 010 AO Pin)* both for heating and for cooling. An external contact *(Overheat DI Pin)* is used for switching between the heating and cooling modes. A relay output (*Heater DO Pin)* is used for circulation pump control.

4.8. CIRCULATION PUMP CONTROL

In case of water heating, a circulation pump is controlled as well. Circulation pump is activated upon demand for heating. When there is no need for heating, the circulation pump is switched off after the set Pump *minimal working time.*

	Min (minutes)	**Max (minutes)**
Pump minimal working time	10	30

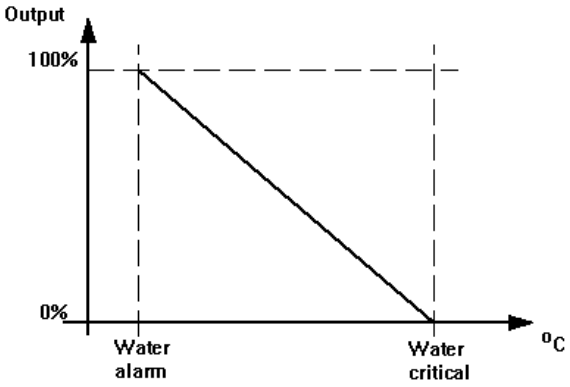
Pump check is performed at times specified under *Pump exercise* setting. During this inspection, the operation state of the pump is checked (on or off); if the pump is off, it is switched on for a check-up and operated for a time specified in *Pump minimal working time.*

	Min (hours)	**Max (hours)**
Pump exercise	0	120

4.9. PROTECTION AGAINST FREEZING

Water heater protection against freezing is active all the time. Need for heating to avoid freezing is calculated proportionally according to the water temperature and the set *Water critical temp* and *Water alarm temp* limits. The estimated need for heating against freezing is compared to the need of the heating sequence. The heater output is set to the higher value.

When the system operates in a standby mode, *Water critical temp* setting is replaced by *Water critical on standby.* This allows maintaining different water temperature during the standby mode.



	Min(°C)	Max(°C)
Water critical temp	Water alarm temp	50
Water alarm temp	-20	Water critical temp
Water critical on standby	Water alarm temp	50

If the water temperature drops below the set *Water alarm temp* value, water frost risk is issued after 5 seconds, the system switches to an alarm mode, the unit is stopped. Protection against freezing is active for the entire alarm mode duration.

If the outdoor temperature is below the set *Force pump on TOUT bellow* temperature value, circulation pump remains on over the entire period even if there is no need for heating.

	Min(°C)	Max(°C)
Force pump on TOUT bellow	-20	15

5. CHILLER CONTROLLER

The following types of chillers are available (*Chiller type*):

1. Cooling On/Off (Ch.*On/Off*);
2. Cooling 0-10 V (*Ch.0-10V*);
3. Cooling with 3-way valve (*Val. 3 pos*.);

5.1. CHILLER ON/OFF

Cooling On/off is controlled via *Chiller DO Pin* output. The output is triggered when the *Cooling* PI regulator of the cooling sequence reaches the set *DX cooling on by PI* value. The output is

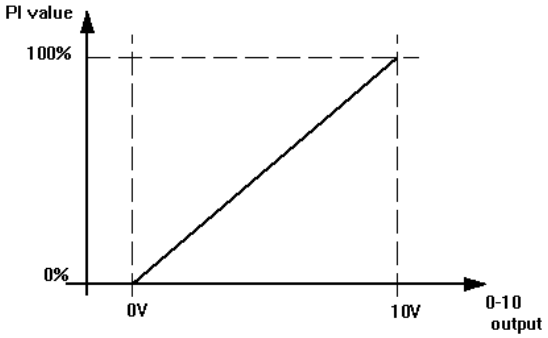
deactivated when *Cooling* PI regulator reaches the set *DX cooling off by PI* value and the minimum cooling time *min DX cooling time* is counted down.

	Min	**Max**
DX cooling on by PI	DX cooling off by PI	99
DX cooling off by PI	0	DX cooling on by PI

	Min (seconds)	**Max (seconds)**
min DX cooling time	0	600

5.2. CHILLER 0-10V

Cooling 0-10V uses a *Cooler 010 AO Pin* output. The output value is set according to a *Cooling* PI regulator value of the cooling sequence.



5.3. CHILLER WITH A 3-WAY VALVE

Chill Valve Up DO Pin and Chill *Valve Down DO Pin* outputs are used for control of a 3-way valve. Depending on whether the need for cooling increases or decreases, a control signal is activated accordingly to open the valve (*Chill Valve Up DO Pin*) or to close it (*Chill Valve Down DO Pin*). Valve opening period - 150 sec. After opening the valve to the extent needed, the signal turns off. Later this signal is activated on demand to close or open the valve. When the need for cooling is 0%, *Chill Valve Down DO Pin* output is active over the entire period. When the need for cooling is 100%, *Chill Valve Up DO Pin* output is active over the entire period.

6. HEAT EXCHANGER CONTROLLER

6.1. HEAT EXCHANGER CONTROL TYPES

The following types are available:

1. Plate type with a 3-way bypass valve (Bypass 3 Pos)
2. Plate type with a 0-10V bypass valve (Bypass 0-10V)
3. Rotor On/Off (Rotor On/Off)
4. Rotor with 0-10V (Rotor 0-10V)

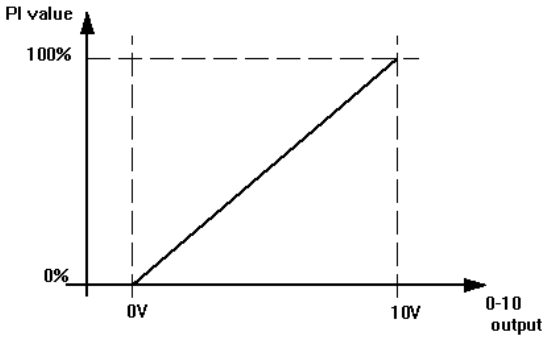
The heat exchanger is controlled according to the *Exchange* sequence. Heat exchanger operation mode depends on the outdoor and room temperatures. If the outdoor temperature is higher than the room temperature, the sequence is reversed; i.e., if the need is equal to 0%, the heat exchanger operates at 100%, whereas, if the need is equal to 100%, the heat exchanger operates at 0%, and so on.

6.2. PLATE HEAT EXCHANGER WITH A 3-WAY BYPASS VALVE

Bypass valve is controlled via *Bypass DMP Up DO Pin* and *Bypass DMP Down DO Pin* outputs. Valve opening period - 150 s.

6.3. PLATE HEAT EXCHANGER WITH A 0-10V BYPASS VALVE

Exchanger 010 AO Pin output is used for the bypass valve control. Output dependence on demand:



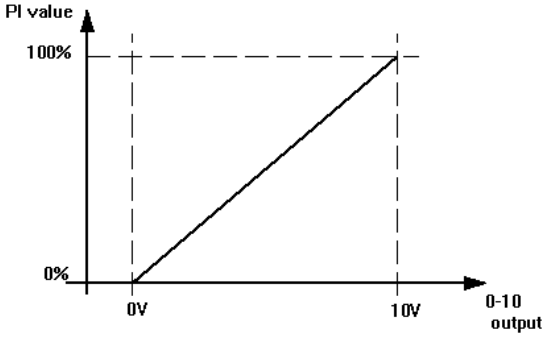
6.4. ROTOR HEAT EXCHANGER ON/OFF

Exchanger DO Pin output is used for the rotor heat exchanger on/off control. 30 sec. output activity periods are calculated according to the need for the *Exchanger* sequence. When the need is equal to 100%, the output is active for all 30 seconds. When the need is equal to 0%, the output is not active. When the need is equal to 50%, the output is on for 15 seconds and off for the remaining 15 seconds.

6.5. ROTOR HEAT EXCHANGER 0-10V

Exchanger 010 AO Pin and *Exchanger DO Pin* outputs are used for the rotor heat exchanger control.

Output dependence on demand:



Exchanger DO Pin output is triggered when the heat exchanger demand exceeds 0%. The output is switched off after 30 seconds, when the heat exchanger demand reaches 0%.

6.6. ROTOR FAULT DETECTION

In systems with a rotor heat exchanger the detection of faults is performed via *Rotor Fail DI Pin* input. If the input is not triggered within 2 minutes when the heat exchanger demand exceeds 0%, a fault is recorded.

7. HEAT EXCHANGER PROTECTION AGAINST FREEZING

The controller has a built-in protection against freezing for the plate heat exchanger. The following tools are used to protect the heat exchanger against freezing:

1. Algorithm to detect the probability of freezing;
2. Elimination of the probability of freezing, deicing of the heat exchanger.

Rotor devices do not have anti-frost protection.

7.1. ALGORITHM TO DETECT THE PROBABILITY OF FREEZING

Algorithm is selected under the *Antifrost detection type* setting. Three algorithms are available:

1. Quadrilateral heat exchanger (*CrossFlow*);
2. Hexagonal heat exchanger (*CountFlow*);
3. By the outdoor temperature (*Toutside*);

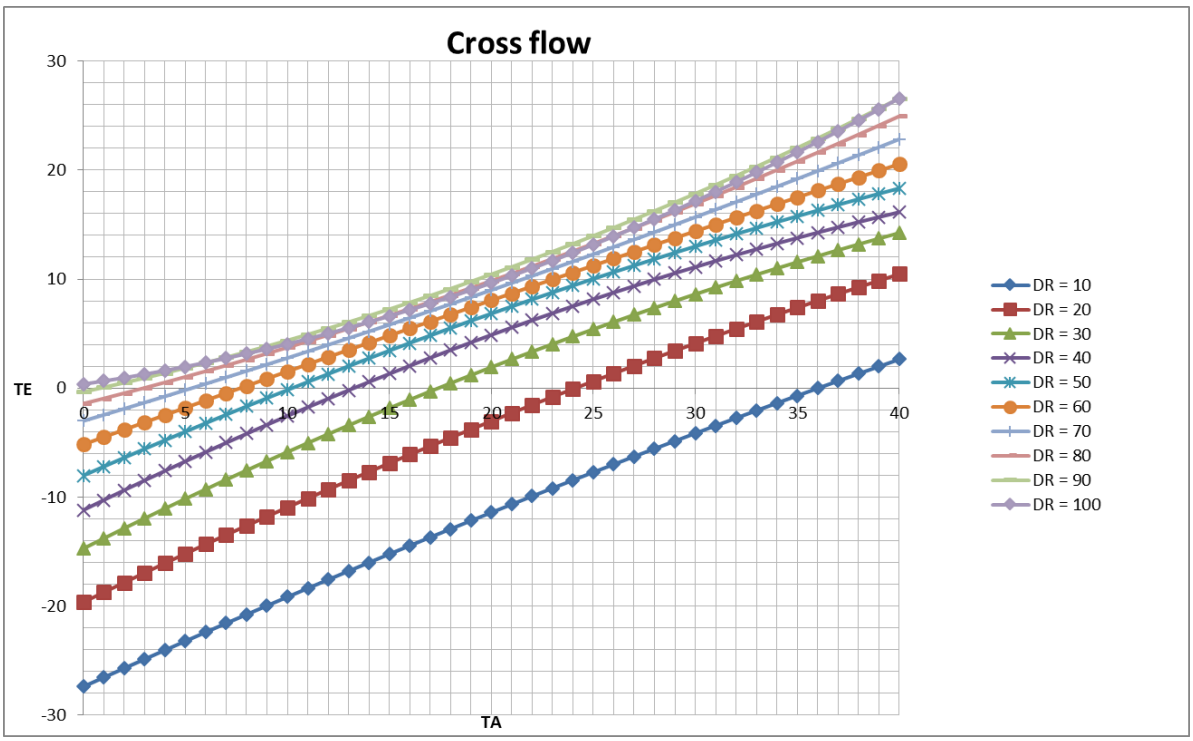
Deicing function of the heat exchanger may be activated via an external *Antifrost DI Pin* contact.

7.1.1 Algorithm for a quadrilateral heat exchanger (Cross flow)

The probability of freezing of the quadrilateral heat exchanger depends on the following factors:

- Room temperature (TA)
- Exhaust air temperature (TE)
- Room humidity (DR)

The probability of freezing is calculated according to the graph (Cross flow). The necessary graph curve is selected according to the current room humidity (DR). If a point of intersection of a suitable room (TA) and exhaust air (TE) temperature in the graph is above the applied (DR) curve, the probability of freezing is detected.

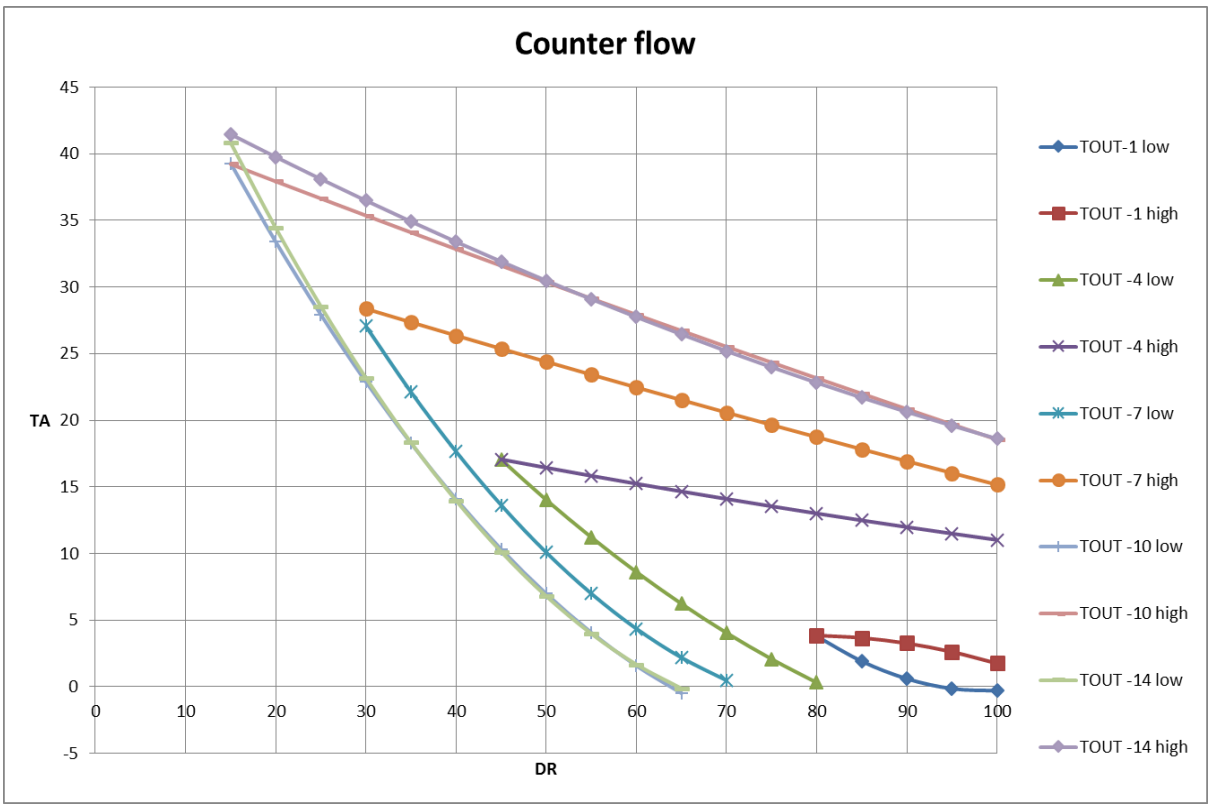


7.1.2 Algorithm for a hexagonal heat exchanger (Counter flow)

The probability of freezing of a hexagonal heat exchanger depends on the following factors:

- Room temperature (TA)
- Room humidity (DR)
- Outdoor temperature sensor (TOUT)

The probability of freezing is calculated according to the graph (Counter flow). Relevant low and high value curves of the graph are used according to the current outdoor temperature value (TOUT). Room temperature (TA) and room humidity (DR) is checked. If the point of intersection of these values is higher than the lowest used curve (TOUT low) or lower than the highest used curve (TOUT high), the probability of freezing is detected.



7.1.3 Algorithm by outdoor temperature

When the outdoor temperature drops below the set *TOUT to start deicing* value, a deicing function is started after 10 sec.

	Min(°C)	Max(°C)
TOUT to start deicing	-30	10

7.2. ELIMINATION OF THE PROBABILITY OF FREEZING

When the probability of freezing is detected, deicing of the heat exchanger is performed. The following tools are used to eliminate the frost risk:

1. External pre-heater control;
2. Bypass valve control;
3. Fan disbalance

Deicing of the heat exchanger is performed for the set *Deicing time*. If the probability of freezing is not removed, the system switches to the SM_DEICINGFAILED mode and the unit is stopped.

	Min (minutes)	Max (minutes)
Deicing time	0	240

The unit may also be stopped when a lower supply air temperature than the set *Low deicing supply air temp* value is detected during the deicing (when the bypass valve is controlled).

After the unit is stopped, the system switches to SM_DEICINGWAITING mode, where the *Start AHU after deicing failed* time is counted down to restart the unit.

	Min (hours)	Max (hours)
Start AHU after deicing failed	1	12

7.2.1 Pre-heater control

2 types of pre-heaters are available:

1. Electrical on/off (El.On/Off);
2. Electrical 0-10 V (El.0-10V);

The purpose of pre-heater - to heat the air supplied from the outside. *Preheater DO Pin* and *Preheater 010 AO Pin* outputs are used for the pre-heater control. If the deicing function is triggered by the outdoor temperature algorithm, the pre-heater is controlled via the Antifrost PI regulator. Otherwise, the pre-heater is turned on at full capacity (100%).

	Min	Max
Antifrost Kp	0.1	100
Antifrost Ki	0.001	10

7.2.2 Bypass valve control

The bypass valve control is switched on via the *Bypass control when deicing* setting. Bypass valve is opened to let the fresh cold air flow through the bypass valve instead of the heat exchanger located in a frost risk zone. In this way, warm extracted (room) air is used to defrost the heat exchanger. *Low supply T when deicing* temperature may be set to avoid supply of excessively cold air. Detection of low temperature of the supply air may be switched off by selecting *Low supply T when deicing = 0.*

	Min(°C)	Max(°C)
Low supply T when deicing	15	18.5

7.2.3 Fan disbalance

Fan disbalance function is turned on using a *Fans disbalance when deicing setting.* When the system is equipped with EC fans, the fan speed is reduced by 20% of the current speed. If the speed

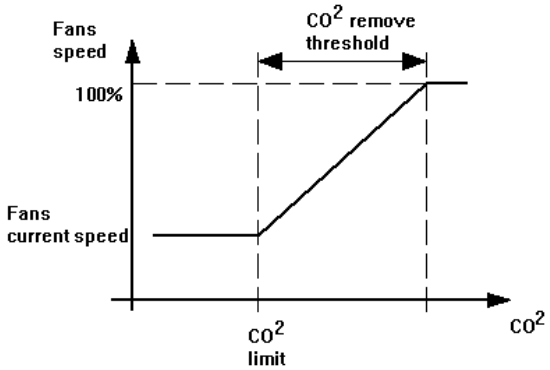
after reduction is lower than 20%, the exhaust fan speed is increased to avoid stopping of the supply air fain. When AC fans are used, Fans *DO 4 Pin* output is activated.

Reduction of a supply air speed creates an effect when the heat exchanger passes through a bigger volume of warm exhaust air than cold supply air. In this way, the frost is thawed.

8. CO2 CONTROLLER

CO^2 controller is intended for removal of excessive CO^2 from the premises. Level is set by the *CO2 limit* parameter. After reaching the set level, CO2 removal is started - fan speed is increased according to the set *CO2 remove threshold* value.

	Min(ppm)	**Max(ppm)**
CO2 limit	CO2 value by 0V	(CO2 value by 10V) –(CO2 remove threshold)
CO2 remove threshold	20	250



Function is activated using a *CO2 function* parameter. Before activating the function, the CO^2 converter must be connected to a *CO2 010 AI Pin* input and parameters *CO2 value by 0V* and *CO2 value by 10V* of the converter must be set.

	Min(ppm)	**Max(ppm)**
CO2 value by 0V	0	CO2 value by 10V
CO2 value by 10V	CO2 value by 0V	2000

9. HUMIDITY CONTROLLER

The humidity controller is intended for maintaining or removing humidity from the premises. The humidity controller has 2 functions: Humidity maintenance and humidity removal functions that adjust the fan speed.

9.1. HUMIDITY MAINTENANCE

Function is activated using a *Low humidity function* setting. Every hour a three-day average of room humidity is calculated (*Three day humidity mean*). When the average of room humidity drops below the set *Low humidity level* limit, low humidity is detected and humidity maintenance function is triggered. The humidity maintenance function sets the fans at the lowest speed and operates for the time set under the *Low humidity timer* setting. If the *Low humidity timer* value is set to 0, then the humidity maintenance function will operate as long as low humidity is detected.

	Min (%)	**Max(%)**
Low humidity level	0	High humidity level

	Min(minutes)	**Max(minutes)**
Low humidity timer	0	240

9.2. HUMIDITY REMOVAL

Function is activated using a *High humidity function* setting. Humidity in the room is measured. When the current room humidity exceeds the set *High humidity level* limit, high humidity is detected and the humidity removal function is activated. The humidity removal function sets the fans at the highest speed and operates for the time set under the *High humidity timer* setting. If the *High humidity timer* value is set to 0, then the humidity removal function will operate as long as high humidity is detected.

	Min (%)	**Max(%)**
High humidity level	Low humidity level	100

	Min(minutes)	**Max(minutes)**
High humidity timer	0	240

10. NIGHT COOLING CONTROLLER

Cooling during the night time (also known as *night cooling* or free *cooling*) is a function to cool the premises using a cool night air. Function is activated using the *Night cooling function* parameter.

During the day ("day" here is a relative term and means the time of day when the controller is in a normal mode) the outside temperature is checked. If the outdoor temperature reaches the set *Night cool day TOUT* temperature, night cooling is permitted. Otherwise, cooling with night air is not allowed.

During the night ("night" is a relative term and means the time of day when the controlled is in standby mode), if the night cooling is allowed, outdoor and room temperatures are checked after the time set in *Start night cool after* setting. If the outdoor temperature exceeds the set *Night cool night TOUT* temperature and the room temperature is higher than *Night cool room TOUT* temperature, night cooling is activated, air supply valves are opened and fans start at the lowest speed. Night cooling continues until the room and outdoor temperatures do not exceed the set values or the standby mode is switched off.

	Min(°C)	**Max(°C)**
Night cool day TOUT	15	40
Night cool night TOUT	0	25
Night cool room TOUT	10	30

	Min(hours)	**Max(hours)**
Start night cool after	0	5

If the night cooling is switched off due to the reached room or outdoor temperature limit, the controller remains in the standby mode and both room and outdoor temperatures are checked again after the set *Start night cool after* time.

11. FILTER CONTROLLER

The filter controller is intended for detection of filter contamination. Possible ways for detection of contamination:

1. External contact (*Filters DI Pin*)
2. Filter timer

11.1.1 External contact

External contact may be connected to pressure relays that measure difference of pressure upstream and downstream the filter. In case of a pressure difference, an external contact is connected and “Change filter” message is activated.

11.1.2 Filter timer

If pressure relays are not used, a filter timer to count working hours of the unit may be used instead. Timer is activated in *Filter timer function* settings. When the timer reaches the *Filter timer limit* a message “Change filter” is activated. After the filter change the timer must be reset in *Filter timer reset* setting. The timer operates in the normal mode only.

	Min(hours)	**Max(hours)**
Filter timer limit	168	6480

12. FIRE ALARM CONTROLLER

System has a built-in fire alarm controller that checks the *Fire Alarm DI Pin* contact state. Contact is checked only when the system is in working mode.

5 seconds after triggering the *Fire Alarm DI Pin* contact, fire alarm is recorded. Upon detection of the fire, ventilation and fans are stopped, the system switches to an alarm mode.

13. SYSTEM OPERATION

13.1. SYSTEM MODES

Possible system modes:

- Standby mode (SM_STANDBY)
- Start-up mode (SM_STARTING)
- Working mode (SM_NORMAL)
- Stopping mode (SM_STANDBYING)
- Stopping mode due to freezing (SM_DEICINGFAILED)
- Waiting mode due to freezing (SM_DEICINGWAITING)

- Emergency mode (SM_EMERGENCY)
- Alarm mode (SM_ALARM)
- Test mode (SM_TESTBOARDIOMODE)

13.1.1 Standby mode

Standby mode may be switched on and off by a controller according to the following requests:

1. External *Stop Ext DI Pin* input.
2. Setting *Set system off*
3. Setting *Set system standby*
4. Fan speed *Stop.*

Request used for activation of the standby mode is also used for switching off. For example, if the standby mode is switched off via an external *Stop Ext DI Pin* input, it must be switched on only via an external contact. If several requests are activated at the same time or one more request is activated in the standby mode, the system resumes from the standby mode only when all requests are resolved.

Actions:

- Calendar commands are checked (if the system is not switched off)
- Night cooling checked/performed
- Water heater protection against freezing is executed (in case of a water heater).
- Requests for switching on/off of the standby mode are checked.

13.1.2 Start-up mode

Actions:

- Overheating hazard of the heater is checked (in case of an electric heater)
- Air supply valve is opened
- Heating is started (in case of a water heater)
- Delay of fan start-up *System start time* is counted down; after the set time the mode is switched to SM_NORMAL

13.1.3 Working mode

Actions:

- Controller settings are updated
- All used controllers are executed
- System crashes are checked
- The system switches to SM_EMERGENCY mode due to:
    1) Faulty sensor (except for a water temperature sensor)
    2) Fire hazard
    3) Faulty fans
    4) Overheated electrical heater
    5) Faulty rotor
- The system switches to SM_ALARM mode due to:
    1) Water temperature sensor fault
    2) Water heater frost risk
- The system switches to SM_DEICINGFAILED mode due to:
    1) Heat exchanger frost risk
    2) Too low supply air temperature during the deicing function of the heat exchanger
- The system switches to SM_STANDYING, when requests for switching on of the standby mode are received.

13.1.4 Stopping mode

Actions:

- Ventilation sequences are disconnected
- Ventilators are stopped (blowdown performed, if needed)
- After stopping the fans, the mode is switched to SM_STANDBY

13.1.5 Stopping mode due to frost risk

Actions:

- Deicing function of the heat exchanger is stopped
- Fan blowdown is executed
- After stopping the fans, the mode is switched to SM_DEICINGWAITING

13.1.6 Waiting mode due to frost risk

Actions:

- Water heater protection against freezing is executed (in case of a water heater).
- *Start AHU after deicing failed* timer is started; after the set time the mode is changed to SM_STARTING

13.1.7 Emergency mode

Actions based on malfunction type

- Overheating of an electrical heater
    a) If *Full fans speed at overheat* is activated, ventilation sequences are stopped and fans are started at the highest speed (*High)*.
    b) If *Full fans speed at overheat* is switched off, fan blowdown is executed and the mode is switched to SM_ALARM.
- Fan fault, fire hazard
    a) Ventilation sequences are stopped, fans are stopped
    b) After stopping of the fans, the system mode is changed to SM_ALARM
- Sensor fault, rotor fault
    a) Ventilation sequences are stopped
    b) Fan blowdown and stopping is executed
    c) After stopping of the fans, the system mode is changed to SM_ALARM

13.1.8 Alarm mode

Actions:

- Water heater protection against freezing is executed (in case of a water heater).

13.2. SYSTEM INDICATION

Work Indication DO Pin and *Stop Indication DO Pin* outputs are used for the system indication.

Mode	**Work Indication DO Pin**	**Stop Indication DO Pin**
SM_STANDBY	off	on
SM_STARTING	On/off every 1 sec.	off
SM_NORMAL	on	off
SM_STANDBYING	on	On
SM_DEICINGFAILED	on	on
SM_DEICINGWAITING	off	On/off every 3 sec.
SM_EMERGENCY	On || off	On/off every 1 sec.
SM_ALARM	off	On/off every 2 sec.
SM_TESTBOARDIOMODE	off	off

13.3. SYSTEM FAILURES

Possible faults:

- Faulty sensor (SA_SENSOR)
- Fire hazard (SA_FIRE)
- Faulty fans (SA_FANFAIL)
- Faulty electrical heater (SA_ELHEATER)
- Faulty rotor (SA_ROTORFAIL)
- Faulty water temperature sensor (SA_WATERSENS)
- Water heater frost risk (SA_WATHEATER)
- Heat exchanger frost risk (SA_FROSTRISK)
- Supply air temperature too low (SA_LOWSUPPLYAIR)

14. SCHEDULE CONTROLLER

The controller may be operated manually when the speed and desired temperature are set manually, or in a calendar mode, when the speed and desired temperature are set according to calendar events. Calendar function is activated with a *Schedule state* setting.

Calendar function, based on the set day of the week (1,2,3,4,5,6,7), turns on a desired fan speed and room temperature at a specified time. Up to 8 calendar commands may be set for the same day. Different commands may be set for every day of the week. Commands may be set using a remote controller of modbus.

When the calendar detects that it's time to run a command, a command to the controller for changing the fan speed and desired room temperature is sent. The set fan speed and room temperature will remain until the other set command is executed or until these parameters are changed via remote control or a modbus command.

Weekday				
Event No.	Hour	Minute	Fans speed	Temp. setpoint
1.	8	0	2 (midd)	22
2.	10	30	1 (low)	19
3.	12	30	1 (low)	18
4.	14	40	3 (high)	18
5.	15	0	1 (low)	19
6.	17	30	1 (low)	23
7.	21	0	1 (low)	22
8.	22	30	0 (stop)	20

15. SYSTEM LOG

Malfunctions or activated functions are recorded and stored in history. Systems stores up to 20 events, indicating time and type of the event. Recorded events:

- Supply air sensor alarm
- Outside air sensor alarm
- Extract air sensor alarm
- Exhaust air sensor alarm
- Humidity sensor warning
- Water sensor alarm
- Exchanger deicing active
- Exchanger frost risk detected
- Low supply air temp. detected
- Fire alarm
- BOOST active
- Overheat alarm
- Rotor Fail Alarm
- Low RH Function Active
- High RH Function Active
- Night Cooling Active
- CO2 Function Active
- Water Heater AF Active
- Water Heater Frost Risk

16. CONFIGURATION OF INPUTS/OUTPUTS OF SYSTEM CONTROLLERS

DO	Regular
Heater DO Pin	K1 - K7, TB1, TB2, TB3
Preheater DO Pin	K1 - K7, TB1, TB2, TB3
Exchanger DO Pin	K1 - K7, TB1, TB2, TB3
Chiller DO Pin	K1 - K7, TB1, TB2, TB3
Heat Valve Up DO Pin	K1 - K7, TB1, TB2, TB3
Heat Valve Down DO Pin	K1 - K7, TB1, TB2, TB3
Bypass DMP Up DO Pin	K1 - K7, TB1, TB2, TB3
Bypass DMP Down DO Pin	K1 - K7, TB1, TB2, TB3
Work Indication DO Pin	K1 - K7, TB1, TB2, TB3
Stop Indication DO Pin	K1 - K7, TB1, TB2, TB3
Air Damper DO Pin	K1 - K7, TB1, TB2, TB3
Fans DO 1 (SAF) Pin	K1 - K7, TB1, TB2, TB3
Fans DO 2 (EAF) Pin	K1 - K7, TB1, TB2, TB3
Fans DO 3 Pin	K1 - K7, TB1, TB2, TB3
Fans DO 4 Pin	K1 - K7, TB1, TB2, TB3
Chill Valve Up DO Pin	K1 - K7, TB1, TB2, TB3
Chill Valve Down DO Pin	K1 - K7, TB1, TB2, TB3

DI	Regular
Overheat DI Pin	ADI1, ADI2, ADI3, TB1, TB2, TB3
Rotor Fail DI Pin	ADI1, ADI2, ADI3, TB1, TB2, TB3
Fans Boost DI Pin	ADI1, ADI2, ADI3, TB1, TB2, TB3
Stop Ext DI Pin	ADI1, ADI2, ADI3, TB1, TB2, TB3
Fire Alarm DI Pin	ADI1, ADI2, ADI3, TB1, TB2, TB3
Antifrost DI Pin	ADI1, ADI2, ADI3, TB1, TB2, TB3
Filters DI Pin	ADI1, ADI2, ADI3, TB1, TB2, TB3
FanFail DI Pin	ADI1, ADI2, ADI3, TB1, TB2, TB3
SAF RPM DI Pin	ADI1, ADI2, ADI3, TB1, TB2, TB3
EAF RPM DI Pin	ADI1, ADI2, ADI3, TB1, TB2, TB3

AO	Regular
Heater 010 AO Pin	AO1, AO2, AO3, AO4, TB1, TB2, TB3
Preheater 010 AO Pin	AO1, AO2, AO3, AO4, TB1, TB2, TB3
Cooler 010 AO Pin	AO1, AO2, AO3, AO4, TB1, TB2, TB3
Exchanger 010 AO Pin	AO1, AO2, AO3, AO4, TB1, TB2, TB3
SAF 010 AO Pin	AO1, AO2, AO3, AO4, TB1, TB2, TB3
EAF 010 AO Pin	AO1, AO2, AO3, AO4, TB1, TB2, TB3

AI	Regular

SAF 010 AI Pin	ADI1, ADI2, ADI3
EAF 010 AI Pin	ADI1, ADI2, ADI3
CO2 010 AI Pin	ADI1, ADI2, ADI3

SI	**Regular**
Supply Air Temp Sens Pin	SI1
Outside Air Temp Sens Pin	SI2
Extract Air Temp Sens Pin	SI4/SI5
Extract RH Sens Pin	SI4/SI5
Exhaust Air Temp Sens Pin	SI3
Water Air Temp Sens Pin	ADI1

0-10V outputs may be inverted:

AO	**Not inverted**	**inverted**
SAF 010 output Inversion	0-10	10-0
EAF 010 output Inversion	0-10	10-0
Heater 010 output Inversion	0-10	10-0
Exchanger 010 output Inversion	0-10	10-0
Chiller 010 output Inversion	0-10	10-0
Preheater 010 output Inversion	0-10	10-0

Setting of normal condition in digital DI inputs

DI	**State**	
Overheat DI normal state	Normally open (NO)	Normally close (NC)
Rotor DI normal state	Normally open (NO)	Normally close (NC)
Boost DI normal state	Normally open (NO)	Normally close (NC)
Stop DI normal state	Normally open (NO)	Normally close (NC)
Fire DI normal state	Normally open (NO)	Normally close (NC)
Antifrost DI normal state	Normally open (NO)	Normally close (NC)
Filters DI normal state	Normally open (NO)	Normally close (NC)
Fan Fail DI normal state	Normally open (NO)	Normally close (NC)