VECTOR®

TRA-F121-A
Fancoil controller with Modbus RTU communications

This manual describes the commissioning of the fancoil controller TRA-F121-A.
TRA-F121-A is a Modbus slave device that controls the room temperature. It has a built-in temperature sensor and controls line voltage valves for heating or cooling and 3 speed fans. Two inputs read open contact or temperature signals and may be configured as automatic heat/cool switch, occupation sensor and more.

Applications
- Fan coil systems
  - 2-pipe fancoil (cooling or heating ON/OFF valve)
  - 2-pipe fancoil with 3-position valve (cooling or heating valve)
  - 2-pipe fancoil and electric heater
  - 4-pipe fancoil (cooling and heating ON/OFF valve)
- Floor heating systems (ON/OFF or 3-position valve)
- Chilled ceilings or chilled beams systems (ON/OFF or 3-position valve)

Functions
- Flush mount on all 75x75x40mm wall mounting box or larger boxes
- Comfort, Economy and Protection mode
- ON/OFF and 3-position valve control
- 110 – 230VAC operating voltage
- Manual or automatic heating / cooling changeover
- Room temperature control via built-in temperature sensor
- Selection of application via parameter
- Select operating mode via operating mode button on the thermostat
- 1- or 3-speed fan control (automatically or manually)
- Display of current room temperature or setpoint in °C or °F
- Display of outdoor temperature received from Modbus master
- Minimum and maximum limitation of room temperature setpoint
- 2 configurable inputs temperature or digital
- Key lock function
- Floor heating temperature limitation
- Reload default settings for commissioning and control parameters
- RTU Modbus slave

1. Technical specifications

1.1. Important notice and safety advice

This device is for use as an operating controller. <u>It is not a safety device</u>. Where a device failure could endanger human life and property, it is the responsibility of the client, installer and system designer to add additional safety devices to prevent such a device failure. Ignoring specifications and local regulations may cause equipment damage and endangers life and property. Tampering with the device and misapplication will void warranty.

Power supply	Power requirements	110 – 250 V AC, 50/60 Hz
	Power consumption	Max. 5 VA
	Electrical connection	Screw terminals Wire 0.15…2.05 mm2 (AWG 26…14)
Built-in sensor	Temperature range Accuracy 0…50°C	0…50°C 0.5°C
Signal inputs	Digital and temperature input Temperature range Temperature accuracy Type & range:	Selectable via parameter -20…60°C 0.5°C if 0…50°C 1.0°C if -20…60°C NTC (Sxx-Tn10): -40…140 °C
Signal outputs	Relays outputs	0…250 VAC, resistive load current 5A, inductive 2A.

	Insulation strength
	    between relays and system electronics
	    between neighboring contacts
		
		2500V to EN 60 730-1
		2500V to EN 60 730-1

	Electronic control type	2.B (micro-disconnection)
Network	Hardware interface Max nodes per network Max nodes per segment	RS485 in accordance with EIA/TIA 485 247 128 (TRA-F121-A only)
	Conductors Impedance Galvanic isolation Network topology Recommended maximum length per chain	Shielded Twisted Pair (STP) cable 100 - 130 ohm The communication circuitry is isolated According Modbus manual (Modbus over serial line) 1200 m (4000 ft.)
Modbus	Communication standard Default setting Communication speed (baud rate) Modbus RTU protocol (8 data bits)	Modbus RTU (www.modbus.org) 38400 baud rate, even parity, 1 stop bit 2400, 4800, 9600, 19200, 38400, 57600, 115200 no parity – 1 or 2 stop bits; even or odd parity – 1 stop bit

Environment	Operation
	    Climatic conditions
	    Temperature
	    Humidity
		To IEC 721-3-3
		class 3K5
		0…50 °C (32…122 °F)
		<85 % RH non-condensing

	Transport & storage
	    Climatic conditions
	    Temperature
	    Humidity
	    Mechanical conditions
		To IEC 721-3-2 and IEC 721-3-1
		class 3K3 and class 1K3
		-25…70 °C (-13…158 °F)
		<95 % RH non-condensing
		class 2M2

Standards	CE EMC conformity Low voltage directive	2014/30/EU 2014/35/EU
	Automatic electrical controls for household and similar use Special requirement on temperature dependent controls	EN 60730 – 1 EN 60730 – 2 – 9
	Electromagnetic compatibility for industrial and domestic sector	Emissions: EN 60730-1 Immunity: EN 60730-1
	Overvoltage category	II (EN 60730-1)
	Pollution class	II (EN 60730-1)
	Safety class	II (IEC 61140)
	Degree of protection	IP30 to EN 60529
General	Material	Fire proof PC+ABS plastic (UL94 class V-0)
	Dimensions front part (H x W x D) Dimensions back part (H x W x D)	88 x 88 x 16 mm (3.5 x 3.5 x 0.6 in) 67 x 61 x 25 mm (2.6 x 2.4 x 1.0 in)
	Weight (including package)	Xx g (xx oz)

1.2. Dimensions, mm (inch)
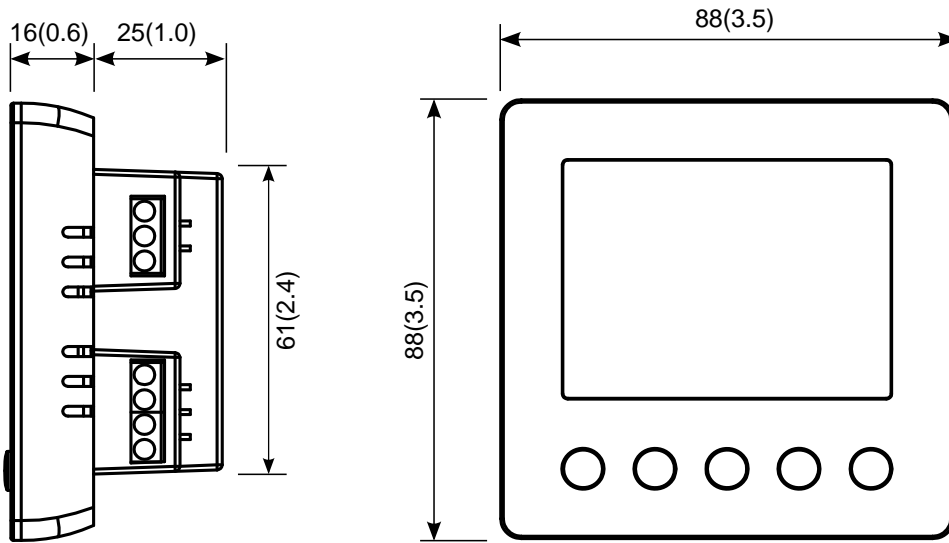
1.3. Installation box

Flush mount on 75x75x35mm box or larger.

Model	Stock code	Type	Size	Weight
AMB-001	40-51 0009	Flush mounting box	80 x 80 x 40 mm (3.2 x 3.2 x 1.6 inch)	40 g
AMB-005	40-51 0010	Surface mounting box	85 x 85 x 37 mm (3.4 x 3.4 x 1.5 inch)	46 g

1.4. Connection diagram
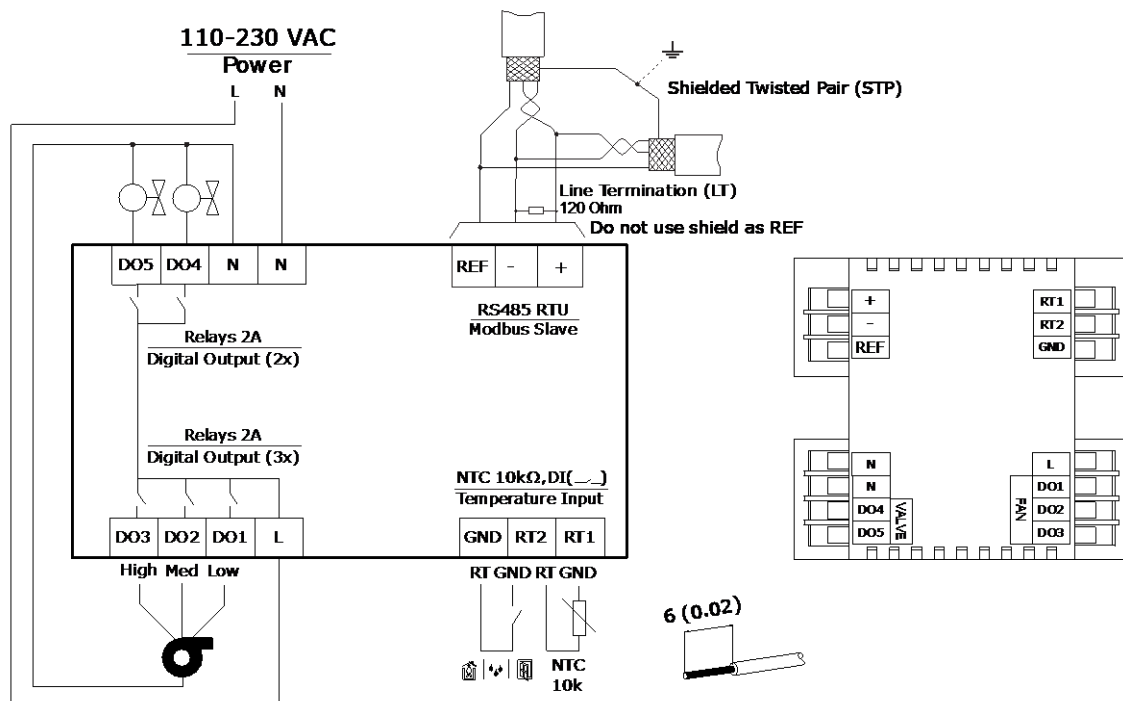
2. Setting up the controller

2.1. Mounting and installation

See installation sheet no. 70-000791 (www.vectorcontrols.com).

2.2. Selection of actuators and sensors

Temperature sensors: Use Vector Controls NTC sensors to achieve maximum accuracy: SDB-Tn10-20 (duct), SRA-Tn10 (room), SDB-Tn10-20 + AMI-S10 as immersion sensor.

Binary auxiliary devices (e.g. fans, on/off valves, humidifiers, etc.): Do not directly connect devices that exceed specified limits in technical specifications – observe startup current on inductive loads.

2.3. Electrical connections

Use only twisted pair copper conductors for input connections. The operating voltage must comply with the requirements for safety extra-low voltage (SELV) as per EN 60 730.

2.4. Power Failure

All parameters and set points are memorized and do not need to be re-entered.

2.5. Modbus wiring

Wire type

An EIA-485 network shall use shielded, twisted-pair cable for data signaling with characteristic impedance between 100 and 130 ohms. Distributed capacitance between conductors shall be less than 100 pF per meter (30 pF per foot). Distributed capacitance between conductors and shield shall be less than 200 pF per meter (60 pF per foot). Foil or braided shields are acceptable.

Line termination

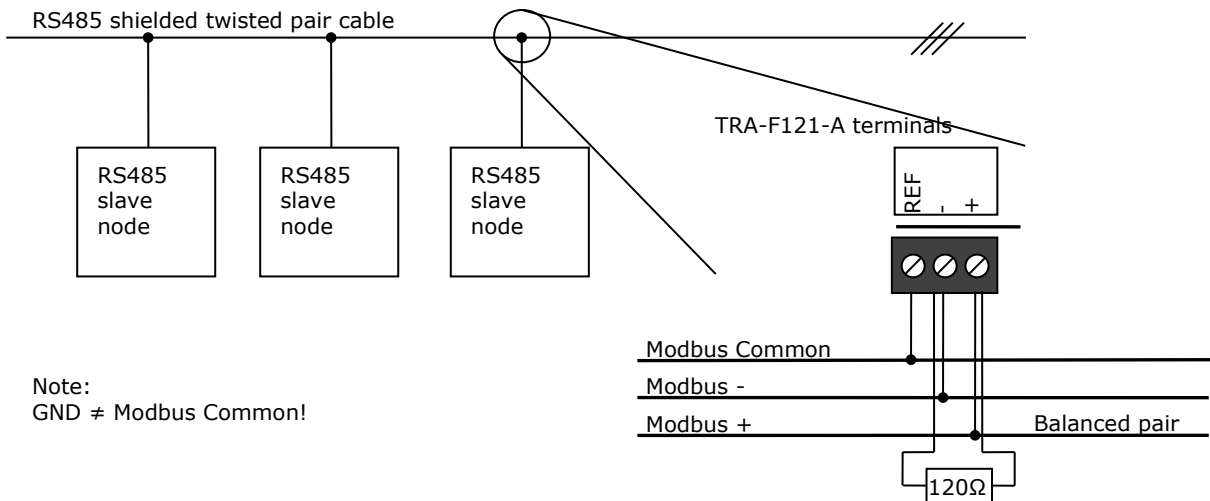On last node on either end of bus only connect 120Ω termination resistor between (+) and (-).

Maximum length

The maximum recommended length per segment is 1200 meters (4000 feet) with AWG 18 (0.82 mm2 conductor area) cable.

Shield connection

See Ashrae Standard 135 for detailed recommendation regarding how to connect the shield depending on type of nodes present in network.
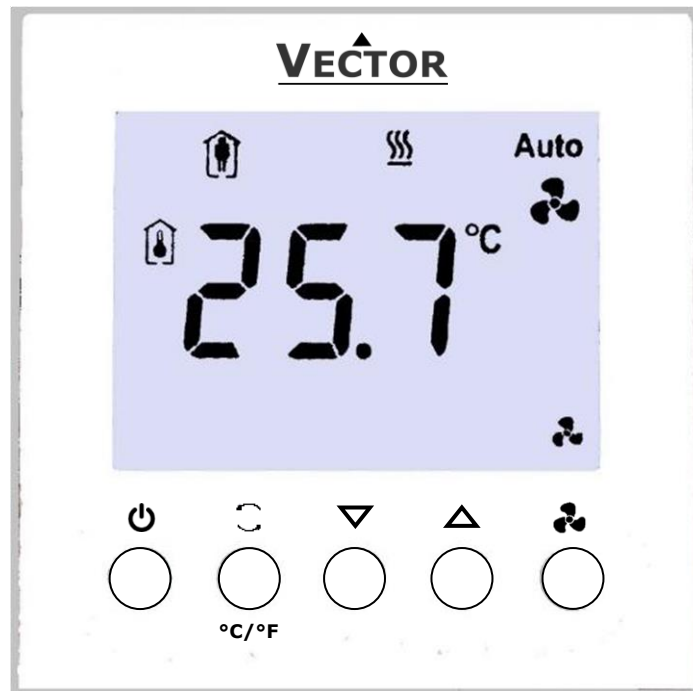
Communication wiring

Note:
GND ≠ Modbus Common!

On last node on either end of bus only:
Connect 120Ω termination resistor between Modbus- and Modbus+.

3. Operation

3.1. User interface

Button operation

Symbol	Function	Description
⏻	Operating mode (Return)	Operating mode selection (comfort, economy, protection) Menu navigation: Return to top menu point
↻	Controlling mode (Return)	Controlling mode selection (heat, cool and fan only) Menu navigation: Return to top menu point Long press: Switch °C/°F
▽	Down (-)	Adjust setpoints and control parameters
△	Up (+)	Adjust setpoints and control parameters
⁂	Fan (Enter, save)	Change fan mode (auto mode or fan speed) Menu navigation: Enter menu point Parameter change: Save parameter

Display
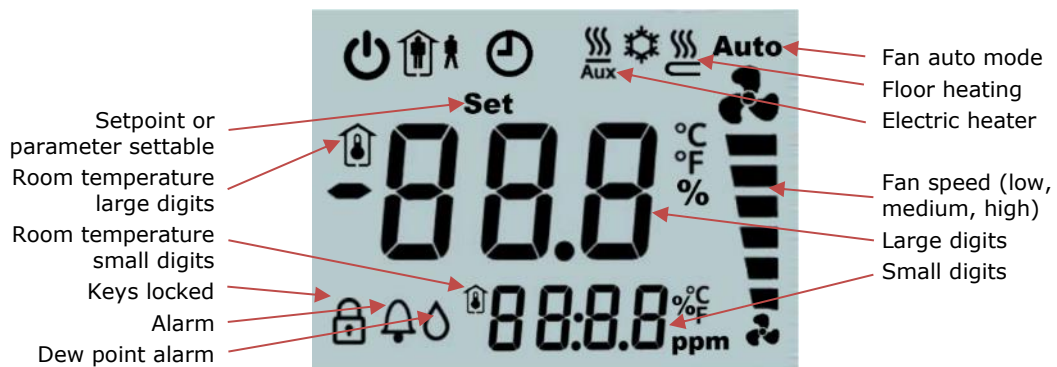
The large digits shows the measured room temperature (default setting) or the comfort setpoint (configurable via parameter P100).

The small digits are off (default setting) or show the outdoor temperature from Modbus master (configurable via parameter P101). Also error and alarm messages are shown on the small digits.

The room temperature and setpoint are given in °C or °F according to P102.

Operation modes

Display	Mode	Description
👤	Comfort	The thermostat maintains the Comfort setpoints defined with parameter P300. In Comfort mode, the fan can be set to auto or manual fan speed: Low, medium or high.
🏠👤	Economy	Thermostat maintains the Economy setpoints defined with parameter P301 and P302.
⏻	Protection	The thermostat runs in standby. The system is protected against overheating and frost if enabled with parameter P303 and P304.
♨	Heating	Heating mode activates heater for temperatures below setpoint. When heating symbol is blinking the heating valve is turned on. Also the electric heater or floor heating symbols are blinking in case of heating valve is turned on.
✺	Cooling	Cooling mode activates cooling equipment for temperatures above setpoint. When cooling symbol is blinking the cooling valve is turned on.
⚘	Fan	The bars between the fan symbols show the fan speed (low, medium, high).

Set parameter via user interface

Press up and down for minimum 3 seconds to enter the password protected parameter menu.
Enter parameter menu with CODE 241.

Error messages

Error messages are shown on small digits:

Small Digits	Error condition
Err1	Built-in temperature sensor error. Sensor is damaged (open or short circuit).
Err2	Temperature sensor RT1/RT2 error. The temperature sensor is not present. Verify wiring or parameter configuration. -99.9 is shown on large digits.
Err3	Digital input error. RT1/2 is not fully opened or closed (resistor between 2.5kOhm and 350kOhm). Verify wiring or parameter configuration.
Err4	Configuration error: A parameter is set in an invalid combination with another parameter. Err4 and one of the conflicting parameter are displayed alternating.
Err5	Time error: Set time and acknowledge error.

Alarm messages

Alarm messages with alarm sign and shown on small digits:

Small Digits	LCD signs	Error condition
ALA1	🔔 Alarm 💧 Dew point	Dew point alarm from RT1/2 (P500/502 = 7)
ALA2	🔔 Alarm	Overheat protection alarm (Only in Protection mode)
ALA3	🔔 Alarm	Frost protection alarm (Only in Protection mode)

3.2. Thermostat operation

The thermostat's operating mode can be switched between Comfort and Economy mode with the operating mode button (⏻). The controller is switched to Protection mode by pressing operating mode button for 2 seconds. If Economy mode is disabled (P103) the thermostat's operating mode is switched between Comfort and Protection mode with the operating mode button.

In Protection mode the system is protected against frost (default 5 °C, see P304) and protected against overheating (default OFF, see P303).

The thermostat's controlling mode can be switched between heating, cooling and fan only with controlling mode button (↻). Depending on the configured application (P200) cooling or heating can't be selected as controlling mode.

The Comfort setpoint can be adjusted with down (▼) and up (▲) button.
Controller changes from economy to comfort mode if up/down button is pressed.
The fan speed can be changed between auto, low, medium and high fan speed with fan button (⚘).

Enable or disable of economy mode and change of setpoint, fan speed, controlling mode or any user operation can be done via parameter settings (see P104 to P108, default is ON and key lock disabled).

3.3. Temperature control

The thermostat measures the room temperature via built-in sensor or external room temperature sensor and maintains the setpoint by controlling the fan speeds and the heating and/or cooling valve (or the electric heater). The following control outputs are available:

- ON/OFF valve
- 3-position valve (only for 2-pipe systems)

The switching differential or proportional band is 2°C for heating mode and 1°C for cooling mode (configurable via parameters P400 and P401).
The integral time is 5 minutes (adjustable via parameter P402 with 300 seconds as default value).

3.4. Thermostat start up

During start up the backlight is lit and all LCD segments are shown. Then the software version and revision is shown on the small digits (format: 1r0, means version 1 revision 0).

After showing the software version the Modbus address can be set by up/down button and stored by fan button (✿). If the address shall not be saved leave the address set menu by pressing operating or controlling mode button (⏻ , ☌).
After 10 minutes the address set mode is left automatically.
If the Modbus address has been set one time the address set menu will not appear anymore. Instead the Modbus address is shown for two second.

After these steps the thermostat runs in comfort, economy or protection mode.

3.5. Power Failure

All parameters and set points are memorized and do not need to be re-entered.
Upon return of power: Based on P110 the thermostat will start in Protection, Comfort or the same mode as before.

4. Configuration (parameter options)

4.1. Parameter usage

Parameter number, resolution and data format

Parameter number and Modbus data address are the same. They are listed in column "Par/Addr" as decimal number.
E.g. P001 is parameter 001 and has Modbus data address 1.

All temperature related parameters are given in °C for Modbus. Only in the user interface values can be shown in °F.
Parameters without multiplier have resolution 1. Parameters with multiplier 10 have resolution 0.1.
For example the default value of comfort setpoint (P300) is 20.0°C and the value read via Modbus is 200 (because of multiplier 10 used for P300).

Parameter with values below 0 (zero) are given as signed integer values.

Modbus function codes

Read multiple register (0x03):
Read n registers (n x 2 bytes) starting from requested address.

Write register (0x06):
Write 1 register (2 bytes) at requested address

Write multiple registers (0x16):
Write n register (n x 2 bytes) starting from sent address.

Note: The read/write capability of each parameter is defined in column "R/W". Most parameters can read and written defined as "R/W". Read only parameters are defined as "R".

Set parameter via user interface

Press up and down for minimum 3 seconds to enter the password protected parameter menu.
Enter parameter menu with CODE 241.

Load and store default settings

Press up and down for minimum 3 seconds to enter the password protected default settings.
Enter default settings with CODE 37. Choose between default TRA-F121-A "dEF" and OEM "OE" configuration copy menu.
Navigate with Up (▲), Down (▼), Enter (⏚) and Return Buttons (⏻, ↻).
After a load or store action the small digits show "Good" and the default settings menu is closed.

Large Digits	Small Digits	Action with Enter Button (⏚)
dEF	no LOAd	No action Load default TRA-F121-A configuration (as described in this manual)
OE	no Load SAVE	No action Load default OEM configuration Save default OEM configuration

Via Modbus the default settings can be accessed by writing 2 registers (with function code 0x16 write multiple registers) to data address 37. After a load or store command via Modbus the small digits show "Good" and the large digits show "CPy" on the operation terminal.

Addr	Description	Required Qty	Data type	R/W
37	Default configuration type	2 registers (function code 0x16: write multiple registers)	0 = Default TRA-F121-A configuration 1 = OEM default configuration	W
38	Action for default configuration		0 = No action 1 = Load config. as defined with address 37 2 = Save actual config. to OEM default (only valid when address 37 = 1)	W

4.2. Modbus settings

Parameter P00x overview

Each Modbus slave device needs a unique device address (ID) in the network. It can be set with P001. All other Modbus network properties can be set with parameter P002, P003 and P006.

With parameter P005 the write access to the parameter via Modbus master is disabled (except P005 can always be written).

P000 and P004 are not used.

Par/ Addr	Description	Data type	Default	R/ W
P001	Modbus device address (ID)	Address range: 1…247	1	R/ W
P002	Baud Rate Modbus RS485	0 = 2400 BPS 1 = 4800 BPS 2 = 9600 BPS 3 = 19200 BPS 4 = 38400 BPS 5 = 57600 BPS 6 = 115200 BPS	4	R/ W
P003	Parity and stop bits	0 = NO Parity, 2 stop bits 1 = EVEN Parity, 1 stop bit 2 = ODD Parity, 1 stop bit 3 = NO Parity, 1 stop bit	1	R/ W
P004	Mode of communication	Not used (always 1 = RTU)	1	R
P005	Allow changing of parameter settings through communication	0 = Not allowed (except P005) 1 = Allowed	1	R/ W
P006	Modbus address PLC style	0 = No offset 1 = PLC address style (+1 address offset)	0	R/ W

4.3. Operating options

Parameter P1xx overview

With parameter P100 – P102 the displayed content can be set.
With parameter P104 – P109 the access via user interface can be restricted.
With P103 the economy mode can be disabled (default is enabled).
With P110 the controller state after power failure can be set.

Par/ Addr	Description	Data type	Default	R/W
P100	Standard temperature display (large digits)	0 = Room temperature (built-in sensor or external NTC on RT1/2) 1 = Setpoint of running operating mode	0	R/W
P101	Display on small digits	0 = No display 1 = Outdoor temperature (via Modbus)	0	R/W
P102	Selection of temperature unit	0 = °C 1 = °F	0	R/W
P103	Enable Economy mode	0 = OFF = Economy mode disabled 1 = ON = Economy mode enabled	1 = ON	R/W
P104	Enable temperature unit change with button (long press)	0 = OFF = Changing disabled 1 = ON = Changing enabled	1 = ON	R/W
P105	Enable change of setpoints via user interface	0 = OFF = Change of setpoints disabled 1 = ON = Change of setpoints enabled	1 = ON	R/W
P106	Enable manual control of fan speeds via user interface	0 = OFF = Manual control of fan speeds via user interface disabled 1 = ON = Manual control of fan speeds via user interface enabled	1 = ON	R/W
P107	Enable manual control of heat/cool/fan only via user interface	0 = OFF = Manual control of heat/cool/fan only disabled 1 = ON = Manual control of heat/cool/fan only enabled	1 = ON	R/W
P108	Key lock (No button operation)	0 = Disabled 1 = Keys locked 2 = Manual lock (Press 3 sec Up (▲) and Down (▼) button, then 3 sec Operating (⏻) and Controlling Mode buttons (↻) to unlock. After 5min without user action the buttons are locked again.)	0	R/W
P109	Enable all parameter for user interface (P001 to P506)	0 = Disable (parameter can only be changed from Modbus master) 1 = Enable (parameter can be changed from user interface)	1	R/W
P110	State after power failure	0 = Protection mode (OFF) 1 = Comfort mode (ON) 2 = state before power failure	2	R/W

4.4. System and output configuration

Parameter P2xx overview

With parameter P200 – P203 the installed application and valve type is selected.
With parameter P204 – P206 the valve characteristics can be set.
With parameter P207 – P214 the fan configuration can be set.

Par/ Addr	Description	Data type	Default	R/ W
P200	Application mode: 2-pipe system: 0…3 4-pipe system: 4…6	0 = Heating only 1 = Cooling only 2 = 2-pipe manual heating or cooling 3 = 2-pipe auto heat/cool changeover 4 = 4-pipe manual heating or cooling 5 = 4-pipe auto heat/cool changeover 6 = 4-pipe Heating and cooling 7 = Floor heating system 8 = Chilled ceiling system	0	R/ W
P201	Enable electric heater	0 = OFF = Electric heater disabled 1 = ON = Electric heater enabled	0 = OFF	R/ W
P202	Not used	-	-	-
P203	Valve type of heating/cooling system	0 = ON/OFF valve 1 = 3-position valve (only for 2-pipe systems)	0	R/ W
P204	3-position valve running time	10…500 sec	150 sec	R/ W
P205	Minimum on time of valve for ON/OFF type	1…30 min	1 min	R/ W
P206	Minimum off time of valve for ON/OFF type	1…30 min	1 min	R/ W
P207	Number of fan speeds	1 = 1 fan speed (only DO3) 3 = 3 fan speeds	3	R/ W
P208	Minimum on time of each fan speed	10…600 sec	120 sec	R/ W
P209	Low fan speed switch on level (Switch off level 15% lower or 0%) Note: Ignored for ON/OFF valve (and electric heater), see chapter 4.6 Control settings	0…25 %	10 %	R/ W
P210	Medium fan speed switching point (Switch off level 15% lower)	30…75 %	60 %	R/ W
P211	High fan speed switching point (Switch off level 15% lower)	80…100%	100 %	R/ W
P212	Fan kick period	0 = OFF = Fan kick disabled 5…1500 = period in minutes	0 = OFF	R/ W
P213	Minimum fan speed in auto mode	0 = Fan off 1 = Low speed	0	R/ W
P214	Minimum fan speed in manual mode	0 = Fan off 1 = Low speed	1	R/ W

Application modes: Valve control diagrams

Detailed explanation of Comfort and Economy Setpoints are given in chapter 4.5 Setpoints.
Detailed explanation of ON/OFF or 3-position valve control are given in chapter 4.6 Control settings.
Detailed explanation of auto heat/cool changeover are given in chapter 4.7 Temperature and digital inputs.
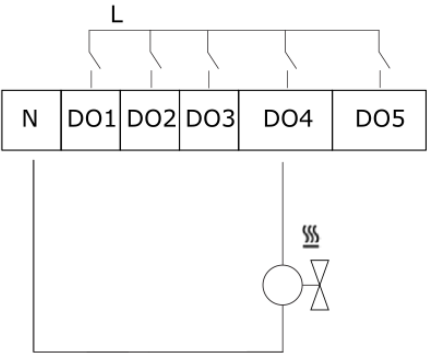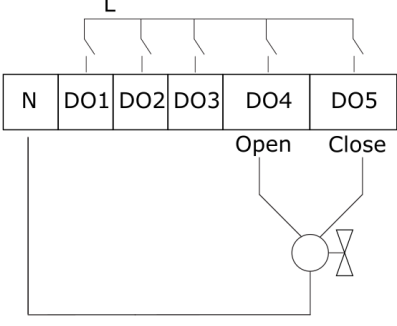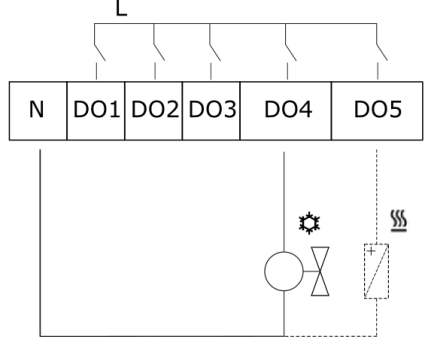
Affected Parameters	Parameter Description
P200	Application mode

Application mode	P200 setting	Valve control diagram (comfort mode)
2-pipe system Heating only	0	W: Comfort setpoint
Floor heating system	7	
2-pipe system Cooling only	1	
Chilled ceiling system	8	
2-pipe system manual heating or cooling	2	User & Modbus
4-pipe system manual heating or cooling	4	
2-pipe system auto heat/cool changeover	3	NTC / DI
4-pipe system auto heat/cool changeover	5	
4-pipe system Heating and cooling	6	

Application modes: Wiring diagrams of outputs

Affected Parameters	Parameter Description
P200	Application mode
P201	Enable electric heater
P203	Valve type of heating/cooling system

System	Wiring diagram of outputs	Parameter settings	
2-pipe system ON/OFF valve DO4: Heating or cooling		P200	0, 1, 2 or 3
		P201	0 = OFF
		P203	0 = ON/OFF valve
2-pipe system 3-position valve Heating or cooling DO4 open valve DO5 close valve		P200	0, 1, 2 or 3
		P201	0 = OFF
		P203	1 = 3-position valve
2-pipe system cooling only with electric heater ON/OFF cooling valve DO4: Cooling DO5: Electric Heater		P200	1 = Cooling only
		P201	1 = ON = Electric heater enabled
		P203	0 = ON/OFF valve
4 pipe system ON/OFF valve Heating and/or cooling DO4: Cooling DO5: Heating		P200	4, 5 or 6
		P201	0 = OFF
		P203	0 = ON/OFF valve

System	Wiring diagram of outputs	Parameter settings	
Floor heating system ON/OFF valve DO4: Heating		P200	7 = Floor heating system
		P201	0 = OFF
		P203	0 = ON/OFF valve
Floor heating / chilled ceiling system 3-position valve DO4 open valve DO5 close valve		P200	7 or 9
		P201	0 = OFF
		P203	1 = 3-position valve
Chilled ceiling system DO4: Cooling DO5: Electric heater (optional)		P200	8 = Chilled ceiling system
		P201	0 or 1 (optional electric heater)
		P203	0 = ON/OFF valve

Manual vs. auto heat/cool change

Manual heating or cooling allows the user interface (via Mode button ↻) and Modbus master to change between heating and cooling. No input (RT1/2) can use the function "Heat/cool changeover" (P400/402 = 2).
To allow only Modbus master control the heat/cool state parameter P107 (Enable manual control of heat/cool/fan only) must be set to 0 = OFF. Modbus master can control the controlling mode (heat/cool/fan only) with P1101.

Auto heat/cool changeover allows one of the inputs (RT1/2, where RT1 has higher priority) to act as a control input for heat/cool changeover. See chapter 4.7 Temperature and digital inputs. User interface and Modbus master control of heat/cool change are disabled in auto heat/cool application (P200 = 3 or 5). Via user interface the user can only change to fan only.

3-position valve control
Output DO4 the OPEN command, output DO5 provides the CLOSE command to the 3-position valve.
The default setting for the valve running time is 150 seconds. It can be adjusted via parameter P204.

Valve synchronization:
- After power up the CLOSE command (DO5) is on for two times the valve running time (P204).
- When the control output is <5% the CLOSE command (DO5) is on for an additional valve running time.
- When the control output is >95% the OPEN command (DO4) is on for an additional valve running time.

Fan overrun for electric heater
When the electric heater is switched off, the fan keeps running for 1 minute to avoid over-heating of the electric heater.

Periodic fan kick
The periodic fan kick is disabled by default settings.
In automatic fan mode if the fan speed is 0 the fan will be set to fan speed 1 periodically with the time defined with P212. The fan runs after this period for the minimum on time for fan speeds (P208).
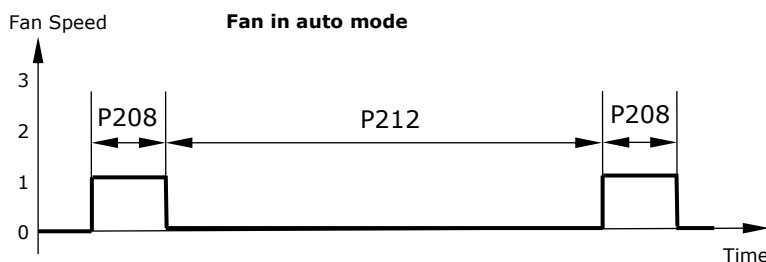
Fan start
When the fan speed comes from speed 0 it starts at speed 3 for 1 second and enters then the calculated fan speed. This is an optimized start for fan motor friction and inertia.
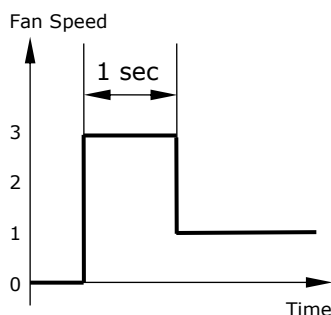
Floor heating system with or without floor temperature limitation
Detailed explanation of floor temperature limitation are given in chapter 4.7 Temperature and digital inputs.
The floor heating system can be configured with or without floor temperature limitation.

Parameter setting...	with floor temperature limitation	without floor temperature limitation
P200 (Application Mode)	7 = Floor heating system	7 = Floor heating system
P500/P502 (Input RT1/RT2 Configuration)	2 = Heat/cool changeover or floor temperature sensor (NTC or DI)	Not 2 (0 - 1, 3 - 7)
P501/P503 (Definition of RT1/ RT2)	0 = NTC temperature sensor	X
P505 (Floor temperature limit)	Set limitation (Default: 30°C)	Ignored

4.5.   Setpoints

Parameter 3xx overview

| Par/ Addr	Description	Data type	Default	R/ W
P300	Comfort setpoint	Multiplier: 10 10.0…40.0 °C	20.0 °C	R/ W
P301	Economy setpoint in Heating mode Heating setpoint < Cooling setpoint	Multiplier: 10 10.0…25.0 °C	15.0 °C	R/ W
P302	Economy setpoint in Cooling mode Cooling setpoint > Heating setpoint	Multiplier: 10 20.0…40.0 °C	30.0 °C	R/ W
P303	Overheat protection temperature point	Multiplier: 10; Integer (signed) 25.0…45.0 °C -0.1 = OFF	-0.1 = OFF	R/ W
P304	Frost protection temperature point	Multiplier: 10; Integer (signed) 0.0…16.0 °C -0.1 = OFF	5.0 °C	R/ W
P305	Minimum setpoint limit in heating mode	Multiplier: 10 10.0…40.0 °C	16.0 °C	R/ W
P306	Maximum setpoint limit in heating mode	Multiplier: 10 10.0…40.0 °C	30.0 °C	R/ W
P307	Minimum setpoint limit in cooling mode	Multiplier: 10 10.0…40.0 °C	14.0 °C	R/ W
P308	Maximum setpoint limit in cooling mode	Multiplier: 10 10.0…40.0 °C	28.0 °C	R/ W

Setpoint types

There are several setpoints with different functionality.

The default setpoint is the comfort setpoint P300. This setpoint may be directly changed by the user through the operating terminal. It is active during comfort mode.

In economy mode the economy setpoint is active (economy heating setpoint P301 in heating mode and economy cooling setpoint P302 in cooling mode).

For protection of the facility overheat protection setpoint P303 and frost protection setpoint P304 can be defined. In default setting overheat protection is disabled.
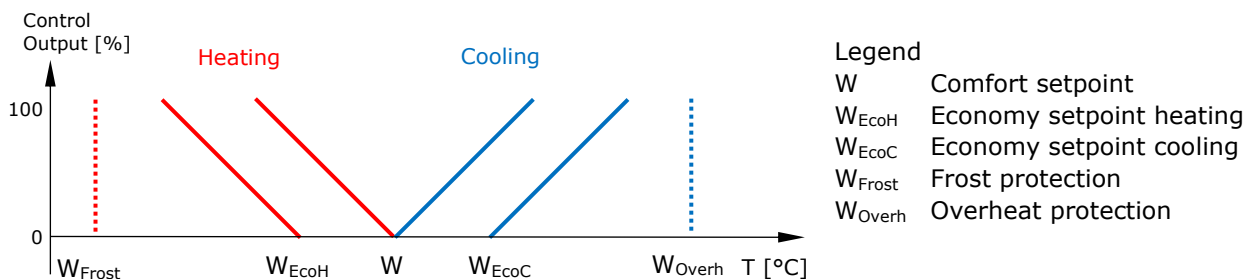
Note 1: If enabled frost protection and overheat protection are only in protection mode active.

Note 2: Comfort setpoint is not compared with economy heating/cooling setpoint nor with frost/overheat protection setpoints. Economy setpoints are not compared with frost/overheat protection setpoints.

Application	Comfort mode		Economy mode	
	Heating	Cooling	Heating	Cooling
2-pipe system Heat only, Cool only, Heat or cool (P200 = 0, 1, 2, 3)				
4-pipe system Heat or cool (P200 = 4, 5)				
4-pipe system Heat and cool (P200 = 6)				

The thermostat acquires the room temperature via built-in sensor or external temperature sensor and maintains the setpoint by delivering actuator control commands to heating and/or cooling equipment.

4.6.   Control settings

Parameter 4xx overview

Par/ Addr	Description	Data type	Default	R/ W
P400	**Heating mode** ON/OFF valve: Switching differential (X_H) 3-position valve: Proportional band (X_{pH}) See P203 for valve type	Multiplier: 10 0.1…10.0 °C	2.0 °C	R/ W
P401	**Cooling mode** ON/OFF valve: Switching differential (X_C) 3-position valve: Proportional band (X_{pC}) See P203 for valve type	Multiplier: 10 0.1…10.0 °C	1.0 °C	R/ W
P402	Integral time Note: For floor heating the integral action is 60 times slower	0 = Integral disabled 10 … 1200 sec Floor heating: 10 … 1200 min	300 sec Floor h.: 300 min	R/ W
P403	Dead zone half span (in comfort mode for cooling and heating application [P200 = 6])	Multiplier: 10 0.1…5.0 °C	1.0 °C	R/ W

Proportional control (proportional band or switching differential)

The proportional control function calculates the output based on the difference between setpoint and measured room temperature. The proportional band (P-band) defines the difference between setpoint and input required to produce a 100% output. For example: a heating control sequence and a 2.0 °C P-band value will produce a 100% output when the input temperature is 2.0 °C below setpoint.

Proportional band (P-band) is the inverted proportional gain. Small P-band values lead to a fast reacting controller (susceptible for oscillation). Large P-band values lead to a slow reacting controller.

Integral control (integral time)

The integral time acts as reset time of a PI control scheme as shown with the following formula.

$$out(t) = \frac{1}{X_{H/C}}\left(e(t) + \frac{1}{T_I}\int_0^t e(\tau)d\tau\right)$$

$$out(t) = Control\ Output\ (heat\ or\ cool)$$
$$e(t) = setpoint(t) - temperature(t)$$
$$X_{H/C} = proportional\ band\ or\ switching\ differential\ (heat\ or\ cool)$$
$$T_I = integral\ time$$

The integral time can be set between 10 and 1200 seconds (20 minutes). The default value is 300 seconds (5 minutes). For room temperature control the integral time should be chosen above 120 seconds (2 minutes) since the temperature change needs in minimum several minutes to take place after heating or cooling valve was changed.

ON/OFF control

The diagrams show the ON/OFF control sequence for all applications except 4-pipe heating and cooling (P200 = 4) which is explained below.

Parameters	Parameter Description	Valid values for given chart
P200	Application mode	Not 6 (0 - 5, 7 - 8)
P201	Enable electric heater	0 or 1
P203	Valve Type	0 (= ON/OFF valve)
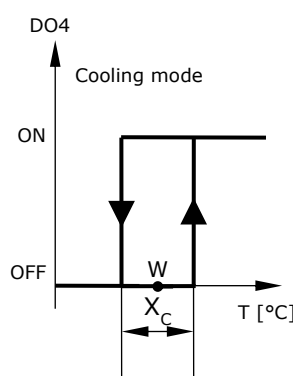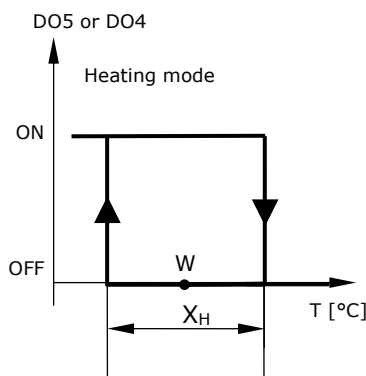
ON/OFF control for 4-pipe application heating and cooling mode

Parameters	Parameter Description	Valid values for given chart
P200	Application mode	6 (= 4-pipe heating and cooling)
P201	Enable electric heater	0
P203	Valve Type	0 (= ON/OFF valve)

Legend

W	Setpoint
X_H	Switching span heating
X_C	Switching span cooling
X_{DZ}	Dead zone half between setpoint and valve switch off
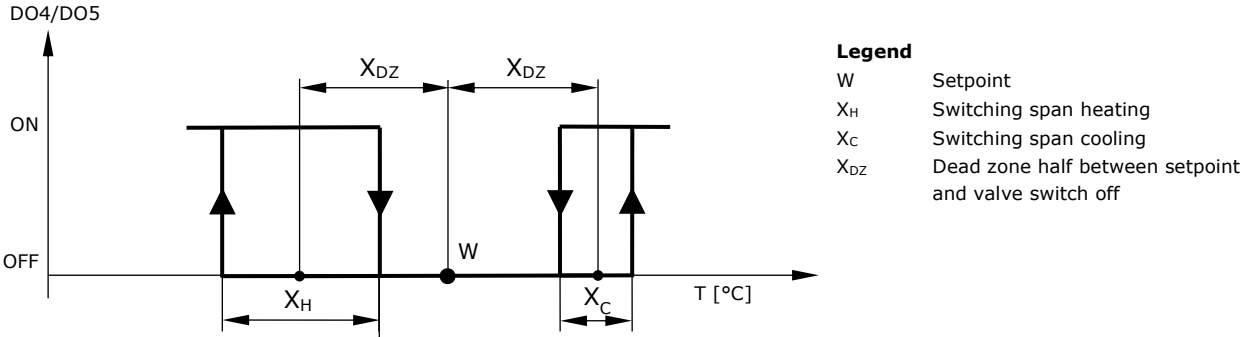
Note: X_H and X_C must be smaller $2*X_{DZ}$.

3-position control

Parameters	Parameter Description	Valid values for given chart
P200	Application mode	0 – 3, 7 - 8
P201	Enable electric heater	0
P203	Valve Type	1 (= 3-position valve)

Legend

X_{pH}	Proportional band heating
X_{pC}	Proportional band cooling
W	Setpoint
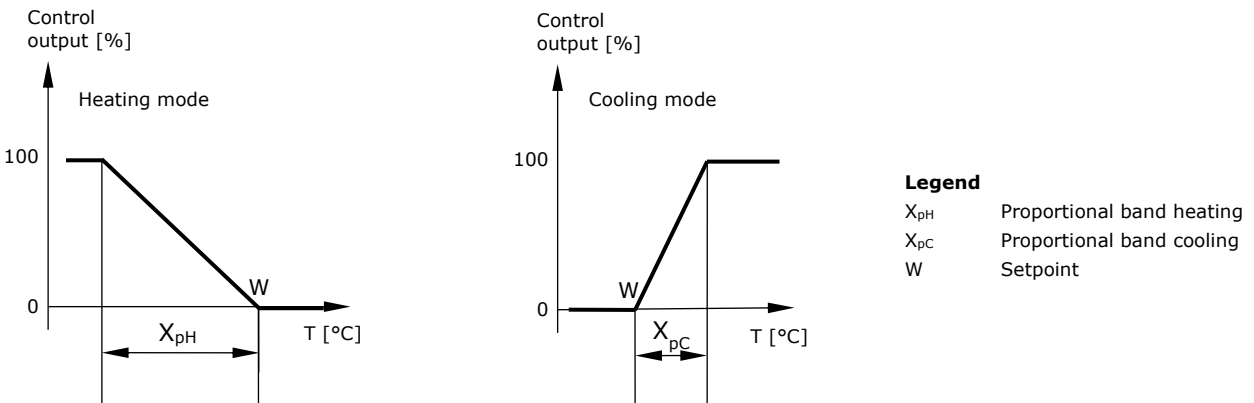
Fan control in automatic mode (ON/OFF control)

Legend

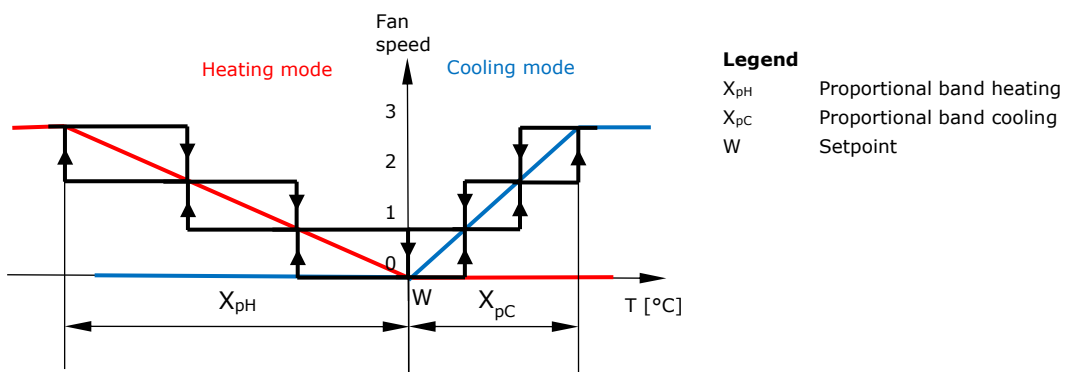|	
W	Setpoint
X_H	Switching span heating
X_C	Switching span cooling
X_{fanH}	Switching span for fan heating
X_{fanC}	Switching span for fan cooling
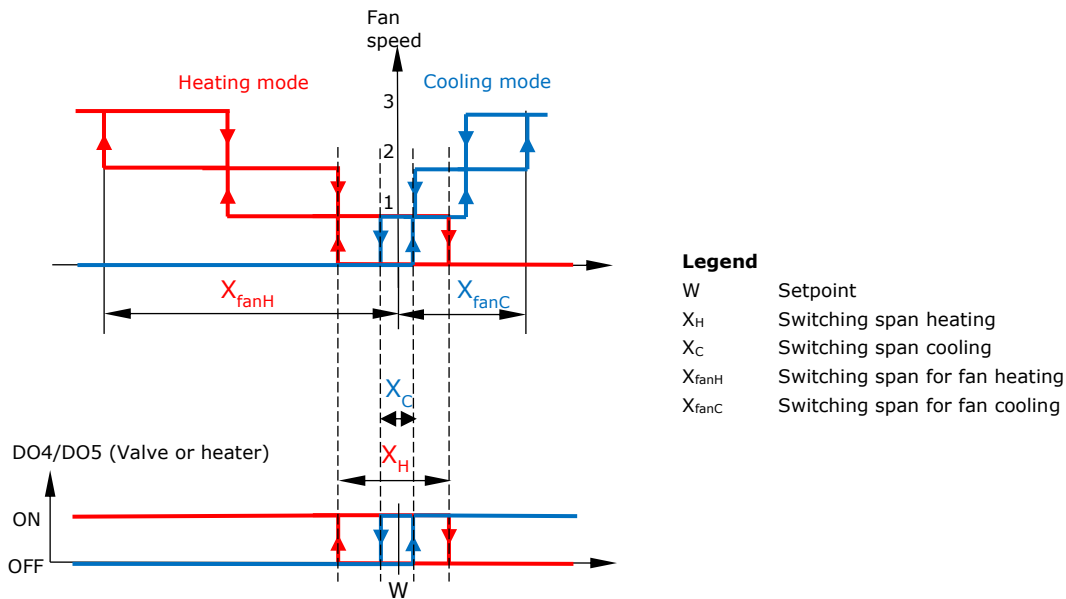
Note:
- Fan is off only if the valve (or electric heater) is turned off.
- This chart shows the fan control for 2-pipe and 4-pipe heating or cooling applications (P200 = 0 to 5).
  For 4-pipe heating and cooling application (P200 = 6) the dead zone between heating and cooling switch point is not depicted.
- This chart assumes P213 (Minimum fan speed in auto mode) is set to 0 = Fan off (default).

Fan speed 1 is aligned with ON/OFF valve (or electric heater). If the valve (or electric heater) switches ON for heating/cooling then fan speed 1 is switched ON. If the valve (or electric heater) switches OFF then fan speed is switched OFF (in case P213 minimum fan speed in auto mode is 0)

X_H / X_C [°C]	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	>4.5
X_{fanH} / X_{fanC} [°C]	2	3	4	5	6	7	8	9	10

Fan control in automatic mode (3-position control)

Legend

X_{pH}	Proportional band heating
X_{pC}	Proportional band cooling
W	Setpoint

4.7. Temperature and digital inputs

Parameter P5xx overview

With parameter P500 – P503 input type and function of RT1 and RT2 can be set.
With parameter P504 – P505 the automatic heat/cool changeover level can be set.
With parameter P506 the built-in temperature sensor calibration (temperature offset) can be set.

For configuration of RT1/2 set to 0 = NTC an error is generated if open or short circuit is detected (Err3).

Par/ Addr	Description	Data type	Default	R/ W
P500	Input RT1 Configuration	0 = Not assigned 1 = Control input instead of built-in temperature sensor (NTC) 2 = Heat/cool changeover or floor temperature sensor (NTC or DI) 3 = Occupation sensor – Comfort / Economy (DI) 4 = Occupation sensor – Comfort / Protection (DI) 5 = Door switch (DI, in combination with occupation sensor on RT2) 6 = Electric heater enable (DI) 7 = Dew point sensor (DI)	0	R/ W
P501	Definition of RT1	0 = NTC temperature sensor 1 = Normally Open (DI) 2 = Normally Closed (DI)	0 = NTC	R/ W
P502	Input RT2 Configuration	0 = Not assigned 1 = Control input instead of built-in temperature sensor (NTC) 2 = Heat/Cool changeover or floor temperature sensor (NTC or DI) 3 = Occupation sensor – Comfort / Economy (DI) 4 = Occupation sensor – Comfort / Protection (DI) 5 = Not used 6 = Electric heater enable (DI) 7 = Dew point sensor (DI)	0	R/ W
P503	Definition of RT2	0 = NTC temperature sensor 1 = Normally Open (DI) 2 = Normally Closed (DI)	1 = NO	R/ W
P504	Automatic heat/cool changeover level for cooling	Multiplier: 10 5.0…20.0 °C	15.0 °C	R/ W
P505	2-/4-pipe system: Automatic heat/cool changeover level for heating Floor heating system: Floor temperature limit	Multiplier: 10 20.0…40.0 °C	30.0 °C	R/ W
P506	Built-in temperature sensor calibration	Multiplier: 10; Integer (signed) -3.0…+3.0 °C	0.0 °C	R/ W

P500/502: 2 = Heat/cool changeover or floor temperature sensor (NTC or DI)
    Heat/cool changeover (NTC or DI)
P200 (Application mode) must be set to 3 or 5. Otherwise an error occurs (Err4).
If P501/503 = 0 = NTC temperature sensor the controlling mode changes to cooling mode if the temperature on RT1/2 is lower than specified in P504. The controlling mode changes to heating if the temperature on RT1/2 is higher than specified in P505.
If RT1 and RT2 are not specified as Heat/cool changeover the controlling mode changes to fan only. If the heat/cool changeover sensor defined as NTC has a short circuit or open contact the controlling mode changes to fan only.

    Floor temperature sensor (NTC)
P200 (Application mode) must be set to 7 (Floor heating system) and the corresponding P501/503 = 0 = NTC. Otherwise an error occurs (Err4).
If the floor temperature sensor exceeds the floor temperature limit (P505) the heating valve is turned off until the floor temperature is 2°C lower than the floor temperature limit.

P500: 5 = Door switch (DI) and P502: 3 or 4 = Occupation sensor (DI)

As soon as P500 is set to 5 = Door switch and P502 is set to 3 or 4 = Occupation sensor the device is configured as "**fool-proof presence detection**". If P502 is set to another value than 3 or 4 an error (Err4 and P502) is shown.

The use of a key switch may be avoided by using a door contact and a motion detector. The room will go to economy mode (P502 = 3) or protection mode (P502 = 4) 60 seconds after the door is opened and closed again and if there is no movement in the room after the door closes (RT2 is evaluated 30 seconds after the door is opened and closed).

The moment there is movement in the room or the door is opened; the room will go to comfort mode again and and stays in comfort mode unless the door is opened and closed again.

The motion detectors should be placed in each room in order to detect the presence of an occupant. Keep the delay of the motion detector output below 30 seconds.

Operating Mode	Comfort Mode	Economy / Protection Mode	Comfort Mode
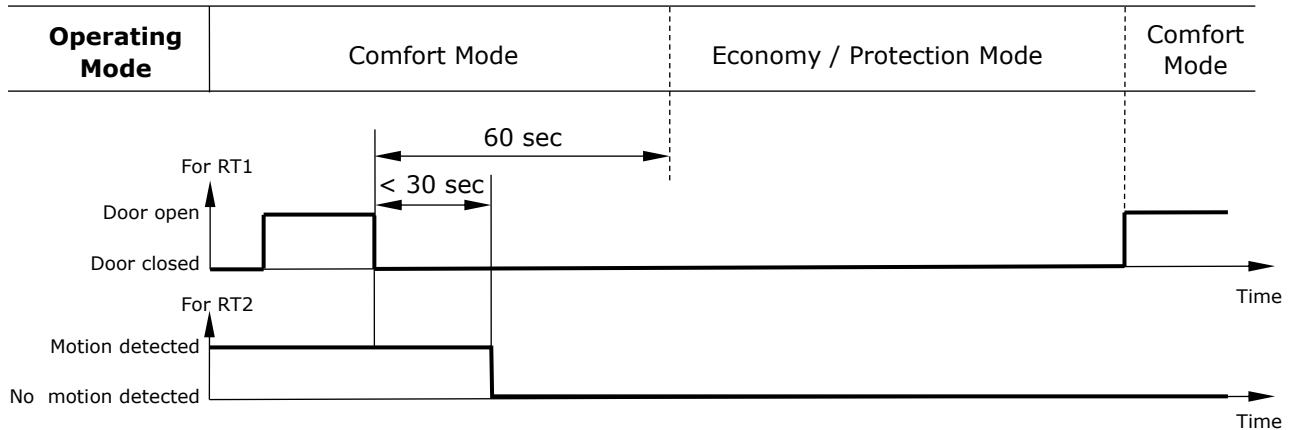
P500/502: 7 = Dew point sensor

Dew point sensor are used for cooling applications (chilled ceiling, etc.) to avoid condensation. A dew point sensor with digital output (open contact) is connected to RT1/2. If there is a condensation alarm the cooling valve is closed and cooling control output is set to 0 (P1301). In cooling mode the fan speed is set to 1 if there is condensation alarm.

P500/502 digital input assignment

If P501/503 is in digital input mode the function or mode assignment for open and close contact are listed here:

Configuration of RT1/2 (P500/502)	Definition of RT1/2 (P501/503)	Contact open	Contact closed
2 = Heat/cool changeover (NTC or DI)	1 = Normally Open (DI)	Heating	Cooling
	2 = Normally Closed (DI)	Cooling	Heating
3 = Occupation sensor – Comfort / Economy (DI)	1 = Normally Open (DI)	Economy	Comfort
	2 = Normally Closed (DI)	Comfort	Economy
4 = Occupation sensor – Comfort / Protection (DI)	1 = Normally Open (DI)	Protection	Comfort
	2 = Normally Closed (DI)	Comfort	Protection
5 = Door switch (DI, in combination with occupation sensor of other input)	1 = Normally Open (DI)	Door closed	Door open
	2 = Normally Closed (DI)	Door open	Door closed
6 = Electric heater enable (DI)	1 = Normally Open (DI)	Electric heater disable	Electric heater enable
	2 = Normally Closed (DI)	Electric heater enable	Electric heater disable
7 = Dew point sensor (DI)	1 = Normally Open (DI)	No alarm	Dew point alarm
	2 = Normally Closed (DI)	Dew point alarm	No alarm

5. Controller status objects

Resolution and data format

All temperature related parameters are given in °C for Modbus. Only in the user interface values can be shown in °F.
Parameters without multiplier have resolution 1. Parameters with multiplier 10 have resolution 0.1.
For example the default value of comfort setpoint (P300) is 20.0°C and the value read via Modbus is 200 (because of multiplier 10 used for P300).

Parameter with values below 0 (zero) are given as signed integer values.

Modbus function codes

Read multiple register (0x03):
Read n registers (n x 2 bytes) starting from requested address.

Write register (0x06):
Write 1 register (2 bytes) at requested address

Write multiple registers (0x16):
Write n register (n x 2 bytes) starting from sent address.

Note: The read/write capability of each parameter is defined in column "R/W". Most parameters can read and written defined as "R/W". Read only parameters are defined as "R".

5.1. Addresstable for controller status objects

Addr.	Description	Data type	Default	R/W
1000	Vector product series information	20 = TRA-F121-A	20	R
1001	Product type information	0 = Standard version	0	R
1002	Controller software version	n = Version n	none	R
1003	Controller software revision	n = Revision n	none	R
1004	Alarm	0 = No alarm 1 = Dew point alarm from RT1/2 (P500/502 = 7) 2 = Overheat protection alarm 3 = Frost protection alarm	0	R
1005	Error	0 = No error 1 = Built-in temperature sensor error 2 = Temperature sensor RT1/RT2 error 3 = Digital input is not open/close 4 = Configuration error 5 = Time error (time not set)	0	R
1100	Operating mode	0 = Comfort 1 = Economy 2 = Protection	0	R/W
1101	Controlling Mode	0 = Heating 1 = Cooling 2 = Fan only	0	R/W
1102	Fan speed value	0 = Fan off 1 = Low Fan 2 = Mid Fan 3 = High Fan	1	R/W
1103	Fan mode	0 = Automatic 1 = Manual (set to manual if fan speed value changed from Modbus master)	0	R/W
1200	Room temperature (Built-in sensor)	Multiplier: 10; Integer (signed) -20.0…60.0 °C -100.0 (= 0xFC18) = Sensor damaged	none	R
1201	External temperature RT1	Multiplier: 10; Integer (signed) -20.0…60.0 °C -100.0 (= 0xFC18= = none (digital input)	none	R
1202	External temperature RT2	Multiplier: 10; Integer (signed) -20.0…60.0 °C -100.0 (= 0xFC18) = none (digital input)	none	R
1203	Outdoor temperature Modbus	Multiplier: 10; Integer (signed) -20.0…60.0 °C -100.0 (= 0xFC18) = no valid temperature received yet	none	R/W
1204	RT1 digital input	0 = OFF 1 = ON -1 = none (Temperature input)	none	R
1205	RT2 digital input	0 = OFF 1 = ON -1 = none (Temperature input)	none	R
1300	Heating control output	0…100 %	none	R
1301	Cooling control output	0…100 %	none	R