thermokon
Sensortechnik GmbH

Description

JOY
Fan Coil Thermostat

Subject to technical alteration

Introduction

Revision

Revision	Date	Description
3	09.12.2015	Issued
4	19.01.2016	Valid with Software version 1.0.12++ - Fan coil assignment to controller mode - Locking of fan coil keys - Override heating/cooling outputs - Cleaning mode - °C/°F display switching - ON/OFF delay - Max heating and coolin loads configurable
5	19.07.2016	Valid with Software version 1.0.14++ - Added hint: Only output heating is active when using change-over - Additional controller modes: - Manual heat respectively cool mode triggering both outputs - Auto heat mode triggering both outputs - Auto cool mode triggering both outputs
6	06.09.2016	Correction of register 6-8 order in chapter 4.1
7	14.11.2016	Valid with application firmware version 1.1.0++ Added PI-controller Added EC-fan coil type Added Startup time fan coil Added Display set point adjustment Added Keycard mode Added Display of controller mode Added Input register “Controller mode“ Added Display automatic mode in Input Register “State fan coil“ Configuration software version 1.2.0.0++
8	18.01.2017	Valid with application firmware version 1.3.0++ and configuration software version 1.3.0.0++ New: Time and date can be faded out New: Display set point offset in main screen New: Special functions for ON-/OFF-Key New: Display application firmware version
9	21.03.2017	Valid with application firmware version 1.4.0++ and configuration software version 1.4.0.0++
10	13.04.2017	Valid with application firmware version 1.4.0++ **Fixed:** Chapter 3.2.5.2: New key combination to invoke Modbus parameter menu
11	16.08.2017	Valid as of application version 1.5.0 ++ and configuration software version 1.5.0.0 ++ NEW: Extension by variant 3AO NEW: Device status after power-on (parameter 130) NEW: Values after power ON (parameter 131) NEW: Input 230V as dew point, window and occupancy contact NEW: Effective relay changeable! NEW: Manual default value for the analog outputs (device type 3AO !!) NEW: Diagnosis menu CHANGED: Value range Switch / control behavior Fan stages NEW: Fan stage keys with / without AUTO NEW: Behavior setpoint offset NEW: Occupied- / ECO-override

1 Device Types Overview

JOY Fancoil 3DI	Item-no. 614757(pwh), 656856(bl)	(3 fan coil stages)
JOY Fancoil RS485 Modbus	Item-no. 614771(pwh), 639453(bl)	(3 fan coil stages)
JOY Fancoil_EC 3DI	Item-no. 649889(pwh), 656863(bl)	(EC-fan coil 0-10V)
JOY Fancoil_EC RS485 Modbus	Item-no. 648363(pwh), 656894(bl)	(EC-fan coil 0-10V)
JOY Fancoil_3AO 24V	Art.-Nr. ######(rws), ######(sw)	(3 analogue outputs)
JOY Fancoil_3AO 24V RS485 Modbus	Art.-Nr. ######(rws), ######(sw)	(3 analogue outputs)

2 General

2.1 Device description

Modern design, flush mounting fan coil room thermostat for controlling a 3 step fancoil (type Fancoil 3DI), an electronic fancoil (type Fancoil EC 3DI). Used for individual control of temperature in commercial, industrial and residential buildings. It is tailored for two-pipe and four-pipe fan coil units with two-wire electric valves. The device combines a modern design with a 2,5” LCD and a touch sensitive surface, 3 time channel options each with 4 time periods options.

2.2 Configuration software

Thermokon provides a configuration software free of charge which can be downloaded from Thermokon website. This software enables the user to create parameter files for the different available device types (3DI and Modbus), which can be stored on a SD card. Remove front panel from device, insert SD card and after power-on device reads and stores a valid parameter file from SD card. Subsequently SD card has to be removed! Devices with intergrated Modbus-interface can also be parameterized by using the Modbus interface.
Further information about the configuration software can be found in chapter **6**.

2.3 Hardware Installation

JOY can be connected by means of twisted pair cables (line resistance 120 Ohm). Detailed information on installation and mounting can be obtained in the JOY product data sheet and the data sheet wiring_rs485_network.pdf.

2.4 RS485 Transceiver

Maximum number of bus participants without use of repeater is defined by the RS485 transceiver. The transceiver used in JOY enables a maximum of 32 devices per bus segment. This constraint is not a timing matter but only for current drive ability of the hardware!

2.5 Protocol

JOY is a Slave bus participant which is only allowed to send data upon request of the Master. The protocol corresponds to the defaults of:
- MODBUS application protocol specification V1.1
- MODBUS over Serial Line Specification & Implementation guide V1.0

2.6 SD-Card

Micro SD cards can be used to upload a new application or a new device configuration. Further information on uploading process can be found in chapter **Bootloader**. With the corresponding PC configuration tool a configuration file can be created and uploaded via SD card. Read more in chapter **Configuration Software**. Only configuration parameters are transferred to the device, marked **(#)** in the Modbus register reference in chapter 5. Please note: All updated parameters are only available after a device reset (after removing the SD card)! Devices from firmware version 1.3.0++ indicate on start screen if an invalid parameter file is found on plugged-in SD card!.
Only cards formatted in FAT-file system are supported. NTFS and exFat are not supported!

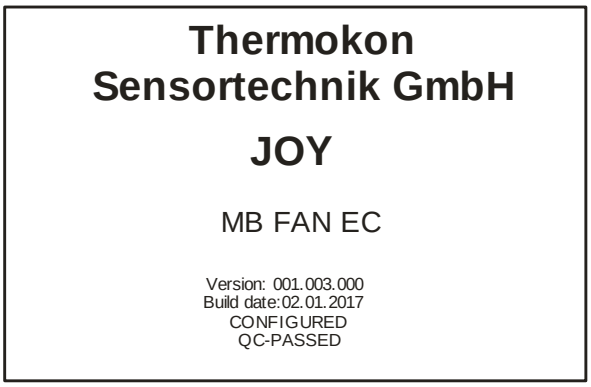
2.7 Boot Loader

Because of an integrated bootloader a new application (update) can be uploaded by means of a SD card. To insert the SD card, the housing cover must be removed. On the Thermokon website you can find the corresponding files under the link http://www.thermokon.de/en/products/room-operating-units/thermostats-fancoil/joy.html under the point Downloads-> Firmware. The zip archives contain the corresponding firmware versions, a small README file (short info on firmware names, device types, etc.) and the software specification belonging to the version number. The update files have the extension * .s19. In case of a downgrade it is strongly recommended to copy a configuration file suitable for the firmware version to the SD card in addition to the firmware file. This ensures that the appropriate configuration file is automatically loaded directly after the firmware downgrade has been completed. This avoids instability due to incompatible firmware and configuration file versions

If the boot loader is activated, the ring illumination blinks in a 1s cycle, while display is not triggered! After recognition of a SD card with a valid application the update process is started. Now, ring illumination blinks in a 300ms cycle. After a successful update process (Duration circa 2-3 minutes!) the new application is started automatically. **Afterwards, SD card shall be removed!**

2.8 Start screen

After power-up or switching from standby to normal mode (button ON/OFF) a start screen is faded in for about 5s, showing information about device type and application firmware version.

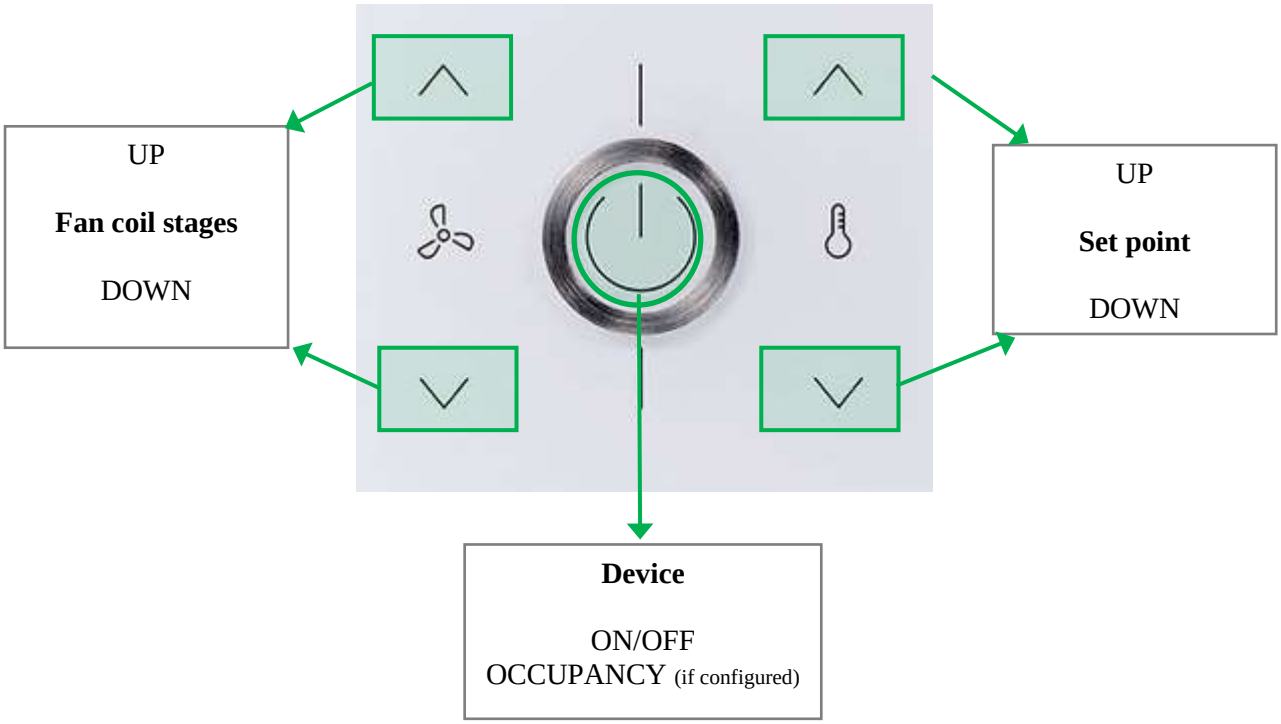


Picture 1: View main screen

3 Menu Guidance

3.1 Main Menu

3.1.1 Keys



Single key actuation releases an action. A longer key actuation enables a cyclical change of the value in 1s cycle. To switch the unit to standby, press the ON / OFF key briefly. If the occupancy function is activated, a short key press changes the occupancy state. To switch the device into standby mode, the ON / OFF button must be pressed at least 3s. In standby mode display and outputs are switched off (controller deactivated). Frost and heat protection remain active. Switching to standby mode is only possible if no digital input is configured as keycard switch.
In case of switching from OFF- to ON-state the start screen is shown for about 5s, displaying device type, application firmware version and build date.

Special function of keys (Parameter)
The center key can be configured with different functionalities. A short key press triggers the special function. A long key press still triggers the ON/OFF function, except if function *Locked* is set. In this case the key is completely locked.

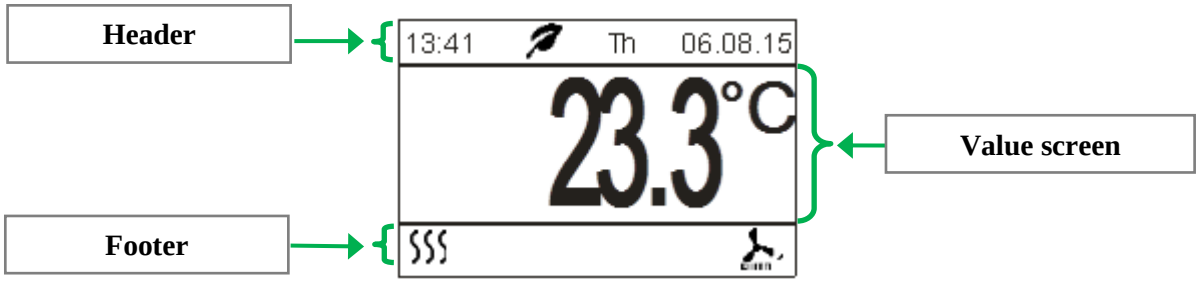
Release of keys
Keys can be released/locked via Modbus at runtime.

3.1.1.1 Holding register

Modbus Holding Register (R/W)	
Register Data Address	**Description**
115	**(#) Special function of key ON/OFF** 0: no special function (ON/OFF active) *(default)* 1: Toggle occupancy 2: Occupied 3: Unoccupied 255 (=0xFF): Locked (ON/OFF disabled)
262	**Release of keys** 0: All keys released *(default)* 1: Lock all keys 2: Lock fan coil keys

3.1.2 Main Screen

The main screen is divided in three fields: header, value screen and footer.



Picture 2: View main screen

Header

The header is designed for displaying time, weekday and date. In addition an info symbol is displayed upon requirement or depending on certain states/modes.

Picture 3: Main screen header

The positions are pre-defined and cannot be changed.

Info Symbols

ECO-Mode
Alarm
Failure Modbus communication

Value Screen

As a standard the value screen shows the room temperature measured by an integrated sensor. If an external sensor is connected and the input is configured accordingly, this value will be indicated in the display. It can be parameterized if room temperature, set point or set point offset shall be displayed.

Picture 4: Temperature display in value range

Upon actuation of any arrow key the display of the value screen changes and shows the associated value. The arrow keys above and under the set point symbol are leading to the set point adjustment screen - the arrow keys above and under the fan coil stage symbol to the fan coil stage adjustment screen. The display switches back to standard screen after 20s without key actuation.

Display of Set point

Picture 5: Display of set point adjustment

After actuation of the arrow keys for set point adjustment, the display screen changes to the set point adjustment screen. The set point symbol and the set point offset value are displayed. Another actuation of one of the two arrow keys modifies the value.
There are three options available for the adjustment mode of the set point. It is possible to adjust the value as an offset value, as an effective value or in stages. As for the display in stages, the values -3, -2, -1, 0, 1, 2, 3 are indicated. Which set point jump corresponds to the individual stages can be set by means of the parameter *set point step size* (address 22). The parameter of the *set point adjustment range* (address 21) has to be adjusted in this way that the value corresponds to stage 3.
See chapter Set point.

Display of fan coil stages

Picture 6: Display of fan coil stage adjustment

After actuation of any arrow key for fan coil stage adjustment, the indication of the value screen changes to fan coil stage adjustment screen. Fan coil stage symbols and the current fan coil stage are displayed. Another actuation of any arrow key switches the fan coil stage.

Footer

In the footer, symbols for process-oriented states such as heating, cooling, room occupancy, window contact etc. are displayed. The symbols are divided into symbol groups. Only one symbol per group can be displayed at the same time.

Symbol Groups

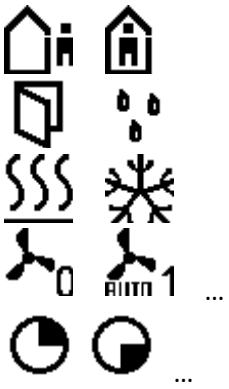
Occupancy

Window contact/dew point

Heating/cooling

Fan coil stage

Active time channel



Five fields are available.

Picture 7: Main screen footer example

Moreover, the positions of the symbols can be freely chosen.
Picture 7 shows a possible configuration. The symbol group fan coil stage is faded-in once a stage different from OFF is switched on, the symbols of group Heating/Cooling only when the controller is in the corresponding mode. The groups Window Contact/Dew Point and Occupancy are only faded-in, if the corresponding mode is configured via an input or set via Modbus. Refer to chapter Inputs. The symbol “Active time channel“ will only be displayed, if a channel is active and no set points are indicated via Modbus.

3.1.3 Holding Register

Modbus Holding Register	
Register Data Address	**Description**
10	(#) Display main screen 0: Room temperature display *(default)* 1: Set point base display 2: Set point offset display
11	(#) Footer symbol 1 $0x00_{hex}$: No symbol *(default)* $0x01_{hex}$: Heating/cooling $0x02_{hex}$: Occupancy $0x03_{hex}$: Window contact/dew point $0x04_{hex}$: Fan coil stage $0x05_{hex}$:Active time channel

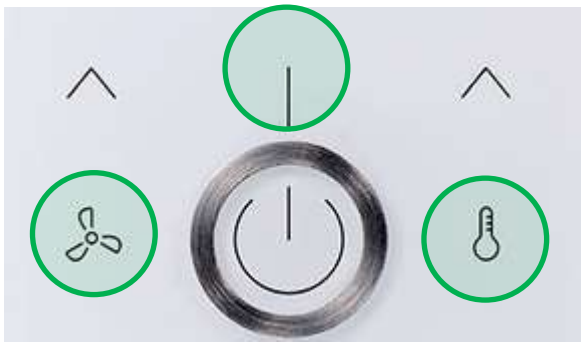
12	(#) Footer symbol 2 See symbol 1
13	(#) Footer symbol 3 See symbol 1
14	(#) Footer symbol 4 See symbol 1
15	(#) Footer symbol 5 See symbol 1
114	(#) Display set point adjustment 0: Set point offset *(default)* 1: Set point base 2: Set point stages (-3,-2, -1, 0, +1, +2, +3)

The registers marked with # are saved in EEPROM. They shall be written only during configuration of the device and not at runtime !

3.2 Parameter Menu

3.2.1 Enter Parameter Menu

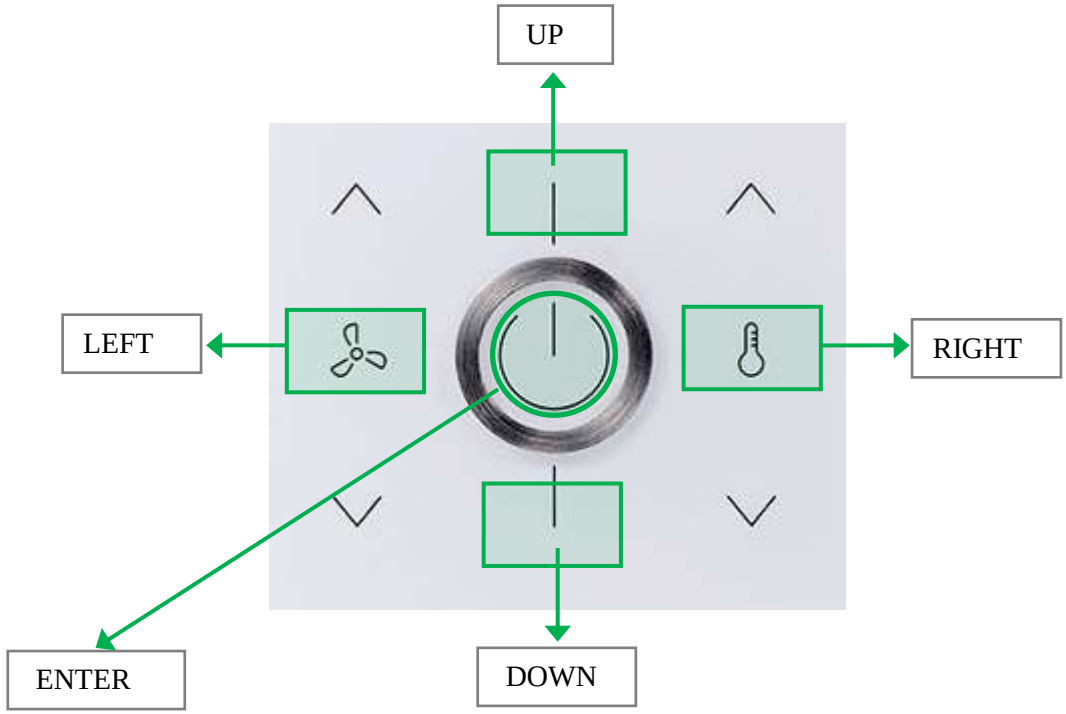
Simultaneous actuation of marked keys for at least 5s. The key combination can be locked by parameter *Lock parameter menu* (address 124), so that a user cannot modify parameters at run time.



Picture 8: Key combination to invoke parameter menu

3.2.2 Keys

Parameter mode is entered by the key combination shown in picture 9. The parameter mode enables users to adapt the time channel parameter (Modbus and 3DI devices) and additional parameters, like Time, Date, Input configuration,… (only 3DI devices) to their own needs directly at the device.



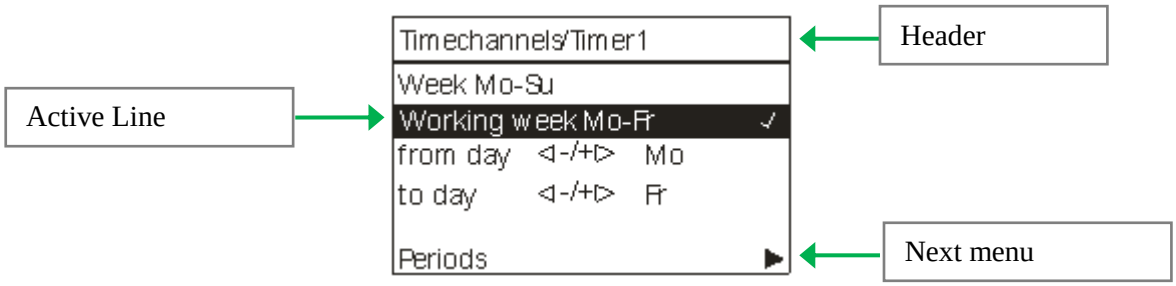
Picture 9: Keys in parameter menu

3.2.3 Exit Parameter Menu

The parameter menu can be left by selecting the header in the main screen of the parameter menu and a key “LEFT“ press afterwards. Device returns automatically to main menu if no key is pressed for 30s.

3.2.4 Navigation

Navigation in menus is made via the keys UP, DOWN, LEFT, RIGHT and ENTER. The menus are build-up hierarchically. Highest level is the main menu. From main menu the user can jump to different submenus. From there, further submenus (if existing) can be entered. To return to previous level, the header must be selected and key LEFT must be actuated afterwards. The keys UP/DOWN are used for selection of a menu line. The currently selected menu line is displayed inverted. A modification of a value can only be made in the selected menu line.



Picture 10: Example of a menu page

The following symbols are used in the menu and enable a better orientation during navigation through the menus:

Value Change

◁-/+▷ The value can be changed by means of keys LEFT(-)/RIGHT(+). No selection via ENTER key necessary.

Invoke next Menu

▶ The next menu can be invoked by means of key RIGHT.

Selection of Display Value

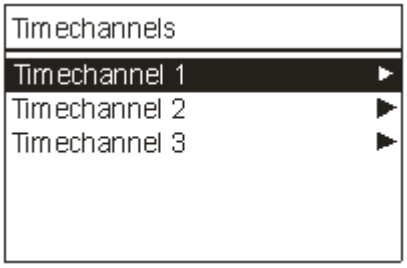
✓ The symbol is faded-in if corresponding value is selected accordingly. Parameters for which no symbol for value change ◁-/+▷ is shown can be selected with key ENTER.

3.2.5 Overview Parameter Menu

The foolwing description relates to the Modbus device. A more detailed description of the menus can be found in the datasheet of the 3DI device.

3.2.5.1 Menu time channel

After actuation of the key combination mentioned earlier in chapter **Enter Parameter Menu** the following menu is shown:



Picture 11 Menu „Choose time channel“

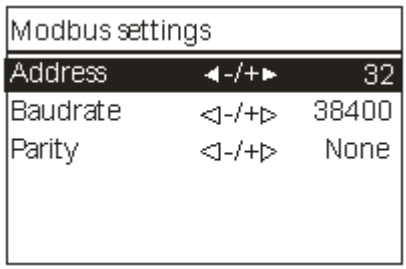
Further information on the parameterization of the time channels can be found in chapter **Time channel**. Up to three time channels with four periods each can be parameterized.

3.2.5.2 Menu Modbus parameter

The menu for Modbus parameter setting is invoked by a simultaneous actuation of the keys marked below for at least 3s. The key combination must be called directly from the main screen. The LED's on the ring light up when the key combination has been detected by the device. **The menu is enabled during the first 60 minutes after switching-on the supply voltage, as long as the device is not actively integrated into a Modbus communication. As soon as the device receives a valid request from a master addressed to the device, access to the menu is blocked. Without valid communication the access is blocked after 60 minutes!!**

Picture 12 Key combination for call of menu Modbus parameter

Afterwards the following Menu appears:



Picture 13: Overview parameter menu modbus

Address
Device address in Modbus network. Adjustable addresses 1-247. Default: 32

Baud Rate
9600Bd
19200Bd *(default)*
38400Bd
57600Bd

Parity
None
Odd
Even *(default)*

3.2.6 Holding Register

Modbus Holding Register	
Register Data Address	**Description**
124	**(#) Lock parameter menu** 0: Key combination released *(default)* 1: Key combination locked

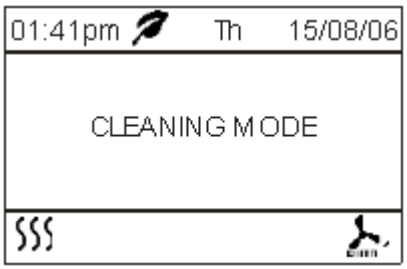
The registers marked with # are saved in EEPROM. They shall be written only during configuration of the device and not at runtime !

3.3 Diagnostic menu

To access the diagnostics menu, select the header in the startscreen of the parameter menu, and press the ENTER key. Here you will find various information, such as device type, software version, state of the inputs and outputs and controller state (current manipulated variable).

3.4 Cleaning mode

By actuating key  for at least 3s, cleaning mode can be entered. All keys are locked. Cleaning mode remains active for 60s.
A short key press invokes the menu for selecting fan coil stages.



Picture 14: Cleaning mode screen

3.5 °C/°F diplay switching

By actuating key  for at least 3s, the temperature unit displayed on screen can be switched between °C and °F. Only screen display is affected! The temperature unit of parameter and process data maintain the unit parameterized in register *Unit temperature* (address 6).
A short key press invokes the menu for modifying set point.

4 Functions

4.1 General Settings

Menu language and a code for device location identification can be configured. Also brightness of background illumination for LCD and ring can be configured in the range of 0-100%. Furthermore, all keys or only fan coil keys can be locked via Modbus and the device can be switched off to standby mode. In standby mode controller is not active and display is off. Moreover, all outputs are switched off and the keys are locked (except for ENTER). Switching to standby mode is only possible if no digital input is configured as keycard switch.

The parameter *Max heating load* is used to optimize the compensation of the self-heating caused by a switched load. If the value is selected, the load current occurring through the heating valve and the fan coil must be considered. Same applies to parameter *Max cooling load*.

The parameter *Device state after power ON* is used to determine the state in which the device starts up (STANDBY / last state / ON). The *Device values after Power ON* parameter allows you to select whether the values for Occupancy, Setpoint Offset, and Fan coil stage resume their last value after power on, or whether they are reset.

4.1.1 Holding Register

Modbus Holding Register (R/W)	
Register Data Address	**Description**
2	**(#)**
3	**(#) Language** 0: German *(default)* 1: English
16	**(#) Brightness background illumination LCD** $0\text{-}100_{dez}$ = 0-100% *Default: 90%*
17	**(#) Brightness ring** $0\text{-}100_{dez}$ = 0-100% *Default: 20%*
99	**(#) Max heating load** 0: <2A *(default)* 1: <4A 2: <6A
100	**(#) Max cooling load** 0: <2A *(default)* 1: <4A 2: <6A
130	**(#) Device state after power ON** 0: Standby 1: Laste state 2: On *(default)*
131	**(#) Device values after Power ON** 0: Keep last values *(default)* 1: Reset values

261	**Device On/Off** 0: On *(default)* 1: Off

The registers marked with # are saved in EEPROM. They shall be written only during configuration of the device and not at runtime !

4.2 Time and Date

4.2.1 Overview

The room thermostat has a real-time clock, which calculates time and date automatically. Besides daylight saving the presentation formats of time and date can be freely configured. The real time clock is buffered by battery, i.e. time and date are kept even in case of longer power failures.
Time and date can be updated during operation by a supervisory system via Modbus.

4.2.2 Holding Register

Modbus Holding Register (R/W)	
Register Data-Address	**Description**
7	**(#) Format time** 0: 24h(pm) *(default)* 64 (=0x40): 12h(am) 255 (=0xFF): not displayed
8	**(#) Format date** 0: TT.MM.JJ *(default)* 1: JJ/MM/TT 255 (=0xFF): not displayed
97	**(#) Daylight saving** 0: disabled *(default)* 1: CET 255 (=0xFF): not displayed
264	**Time hour** 0 – 23 *Default: 12*
265	**Time minute** 0 – 59 *Default: 0*
266	**Date day** 1 – 31 *Default: 1*
267	**Date month** 1 – 12 *Default: 1*
268	**Date year** 15 – 99 *Default: 15*

The registers marked with # are saved in EEPROM. They shall be written only during configuration and not at runtime !

4.3 Time Channel

4.3.1 Overview

There are 3 time channels including 4 periods available, which can be freely programmed. For each time channel a set of weekdays can be selected. Start time, set point, fan coil stage and ECO mode can be parameterized for every period.

Table 1: Structure of a Time Channel

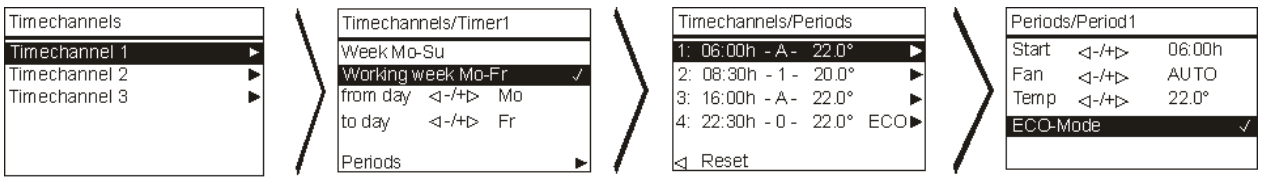
Time Channel		
Weekday mask	**Periods**	**Parameters**
Complete week Mo-So Working week Mo-Fr From day to day	1	Start time
		Fan coil stage
		Set point heating
		ECO mode
	2	Start time
		Fan coil stage
		Set point heating
		ECO mode
	3	Start time
		Fan coil stage
		Set point heating
		ECO mode
	3	Start time
		Fan coil stage
		Set point heating
		ECO mode

A period is activated, if time and weekday are in conformance with the parameterized start time and weekday mask. A period remains active until conditions of another period are fulfilled. Active set point can be overriden over Modbus by means of register *Basic set point* (address 255). For further information see chapter Set point.

Time channels are prioritized. Channel 3 has the highest priority. Parameterization of the device is made in parameter menu or via PC configuration tool, which stores the configuration file on a SD card or transmits the parameter to the device via Modbus (only Modbus devices).

4.3.2 Menu time channel

Up to three time channels, each including 4 periods, can be parameterized. For each period start time, set point, fan coil stage and ECO-mode can be set.



Picture 15: Menu "Selection of Time Channel"

After having selected the line of the time channel that shall be processed, next submenu *Timechannels/TimerX* is invoked actuating key RIGHT. In the first two lines the complete week from Monday to Friday or the working week from Monday to Friday is chosen. Alternatively, any period within a week can be adjusted in lines 3 and 4. The selected time period is marked with symbol ✓ .
In the lower line menu *Periods* can be selected (key RIGHT). In menu *Timechannels/Periods* (3) an overview of all 4 periods of the corresponding time channel is shown first. The adjusted parameters of the corresponding period are displayed in shortened form in the following sequence from left to right.

Index time period / start time / fan coil stage / set point/ info ECO-Mode

After selecting the section to be edited, the key RIGHT can be used to jump to the corresponding submenu. In the bottom line you can reset the settings of the time channel (key LEFT). ATTENTION: The reset clears all settings and can not be undone! To return to the previous menu, move the cursor to the top line and then actuate key LEFT. **Changes of the time channel are stored by return from menu (2) to menu (1) actuating key LEFT**.

4.3.3 Holding register

Start
The start time can be changed in 15 minutes step.

Fan
3 stages fan coil type (3 relays)
Fan coil stage selection between OFF, Stage 1, Stage 2, Stage 3 and AUTOMATIC.
EC fan coil type (0-10V)
Fan coil selection between OFF and AUTOMATIC

Set Point
The set point can be adjusted in the range 0°C to 50°C.

ECO-Mode
In addition, ECO mode can be set (key ENTER). In ECO mode, the dead zone between heating and cooling is set automatically to the configured ECO dead band (standard 10K). Also the pulse-width-modulation cycle time is doubled. If a period with ECO Mode is activated, the ECO symbol is faded-in at the main screen. When the ECO mode is active, the value of the set point offset is not taken into account.

Modbus Holding Register (R/W)	
Register Data Address	**Description**
34	**(#) Time channel 1 weekdays** Bit0: Monday Bit1: Tuesday Bit2: Wednesday Bit3: Thursday Bit4: Friday Bit5: Saturday Bit6: Sunday *Default: 0* Example: 7 ≙ $0x0F_{hex}$ = Monday, Tuesday, Wednesday, Thursday
35	**(#)Time channel 1 period 1: Start time hour** 0 – 23h *Default: 0*
36	**(#)Time channel 1 period 1: Start time minute** 0 – 59m *Default: 0*
37	**(#)Time channel 1 period 1: Set point** 0-500 ≙ 0,0 – 50,0°C *Default: 21,0°C*
3 stages fan coil type (3 relays)	
38	**(#)Time channel 1 period 1: Fan coil stage** 0: Off 1: Stage 1 2: Stage 2 3: Stage 3 4: Automatic *(default)*
EC-fan coil type (0-10V)	
38	**(#)Time channel 1 period 1: Fan coil stage** $0x00_{hex}$: Off $0x01_{hex}$: Automatic *(default)*
39	**(#)Time channel 1 period 1: ECO mode** 0: ECO Mode off *(default)* 1: ECO Mode active
40-44	**(#) Time channel 1 period 2**
45-49	**(#) Time channel 1 period 3**
55-75	**(#) Time channel 2**
76-96	**(#) Time channel 3**

The registers marked with # are saved in EEPROM. They shall be written only during configuration of the device and not at runtime!

A complete register list can be found in chapter **Modbus Register Reference**.

4.4 Temperature

4.4.1 Overview

JOY has an integrated temperature sensor. By default this value is used as actual value for the internal controller. As described in chapter **Inputs** the universal input can be parameterized as a sensor input for an external sensor. In this case, the external sensor value is used as actual value and additionally is indicated as temperature display. Measurement range of the sensor is ranging from 0…50°C with a resolution of 0,1°. For both sensors a calibration to compensate self-heating is possible.

4.4.2 Holding Register

Modbus Holding Register (R/W)	
Register Data Address	**Description**
4	**(#) Offset internal sensor** 0,0 - 15,0°C *Default: 0,0°C*
5	**(#) Offset external sensor** 0,0 - 15,0°C *Default: 0,0°C*
6	**(#) Unit temperature** 0: not implemented 1: °Celsius *(default)* 2: °Fahrenheit

The registers marked with # are saved in EEPROM. They shall be written only during configuration of the device and not at runtime !

4.4.3 Input Register

Modbus Input Register (R)	
Register Data Address	**Description**
514	**Internal temperature sensor** 0-500 ≙ 0-50,0°C Example: 21,5°C = 215
515	**External temperature sensor** 0-500 ≙ 0-50,0°C Example: 21,5°C = 215

4.5 Inputs

4.5.1 Overview

Two digital inputs are available at Modbus type, whereas input 1 is a potential-free universal input and input 2 is a 230V input. The 3DI type has an additional potential-free input. Depending on the selected input different functions such as window contact, dew point contact, occupancy contact, change-over contact, keycard switch and external temperature sensor can be configured which are briefly explained in the following chapters. For every input, polarity can be configured in addition (make contact/break contact).

The internal input state is linked by an OR-function with the corresponding Modbus register when being configured as window or dew point contact. As for occupancy or change-over configuration the corresponding Modbus register overrides the internal state.

Table 2: Overview of possible combinations

Input 230V (Input 2)	Input 3DI (Input 3) (not available with Modbus device)	Input Universal (Input 1)
Change-Over DI Dew point contact Window contact	Window contact	Sensor (NTC10k)
		Window contact
		Dew point contact
		Occupancy contact
		Keycard switch
	Dew point contact	Sensor (NTC10k)
		Window contact
		Dew point contact
		Occupancy contact
		Keycard Switch
	Occupancy contact	Sensor (NTC10k)
		Window contact
		Dew point contact
		Keycard Switch
	Keycard Switch	Sensor (NTC10k)
		Window contact
		Dew point contact
		Occupancy contact
Occupancy contact	Window contact	Sensor (NTC10k)
		Window contact
		Dew point contact
		Keycard Switch
	Dew point contact	Sensor (NTC10k)
		Window contact
		Dew point contact
		Keycard Switch
	Keycard Switch	Sensor (NTC10k)
		Window contact
		Dew point contact
Not used	Change-Over DI	Sensor (NTC10k)
		Window contact
		Dew point contact
		Occupancy contact
		Keycard Switch
	Window contact	Sensor (NTC10k)
		Change-Over DI
		Change-Over Sensor (NTC10k)
		Window contact
		Dew point contact
		Occupancy contact
		Keycard Switch
	Dew point contact	Sensor (NTC10k)
		Change-Over DI
		Change-Over Sensor (NTC10k)
		Window contact
		Dew point contact
		Occupancy contact
		Keycard Switch
	Occupancy contact	Sensor (NTC10k)
		Change-Over DI
		Change-Over Sensor (NTC10k)
		Window contact
		Dew point contact
		Keycard Switch
	Keycard Switch	Sensor
		Change-Over DI
		Change-Over Sensor (NTC10k)
		Window contact
		Dew point contact
		Occupancy contact

4.5.2 Configurabe Functions

4.5.2.1 External Temperature Sensor (NTC10k)

At universal input 1 an external temperature sensor of type NTC10k can be connected. If configures the external sensor value is automatically used as actual value for the internal controller and is shown in display.

4.5.2.2 Change-Over Digital Contact

The input is used as a digital change-over-default for the controller. At maximum one input can be configured as a change-over contact! For further information see chapter **Change-Over**.

4.5.2.3 Change-Over Sensor(NTC10k)

An external temperature sensor of type NTC10k can be connected at the universal input. With this configuration the measured temperature-value determines the change-over-default to the controller. At maximum one input can be configured as a change-over contact! Read more in chapter **Change-Over**.

4.5.2.4 Window Contact

Universal input can be configured as window contact. They are linked by an OR-function. Further information in chapter **Window Contact/Energy hold off** .

4.5.2.5 Dewpoint Contact

Universal input can be configured as dewpoint contact. They are linked by an OR-function . Read more in chapter **Dewpoint**.

4.5.2.6 Occupancy Contact

The input is used as a occupancy contact. At maximum one input can be used as an occupancy contact. Further information to be obtained in chapter **Occupancy**.

4.5.2.7 Keycard Switch

Input will be used as keycard detection. Further information to be obtained in chapter **Keycard Switch**.

4.5.3 Holding Register

Modbus Holding Register	
Register Data Address	**Description**
18	**(#) Input 1: Universal input** 0: Not used *(default)* 1: External temperature sensor (NTC10k) 2: Change-over sensor (NTC10k) 3: Change-over make contact (NO = normally open) 4: Window contact make contact 5: Occupancy make contact 6: Dew point make contact 7: Change-over break contact (NC = normally closed) 8: Window contact break contact 9: Occupancy break contact 10: Dew point break contact 11: Keycard switch make contact 12: Keycard switch break contact
19	**(#) Input 2: 230V** 0: Not used *(default)* 3: Change-over make contact (NO = normally open) 4: Window contact make contact 5: Occupancy make contact 6: Dew point make contact 7: Change-over break contact (NC = normally closed) 8: Window contact break contact 9: Occupancy break contact 10: Dew point break contact

The registers marked with # are saved in EEPROM. They shall be written only during configuration and not at runtime!

4.5.4 Input Register

Modbus Input Register (R)	
Register Data Address	**Description**
519	**State input 1: Universal** 0: Open 1: Closed
520	**State input 2: 230V** 0: Open 1: Closed

4.6 Alarm

It´s possible to fade-in an alarm symbol in the header line of the display. This symbol is at the same position as the ECO symbol. As the alarm symbol has a higher priority, the ECO symbol is overridden. If an alarm is active, the background illumination of the LCD is blinking.

Picture 16: Header with faded-in alarm symbol

4.6.1 Holding Register

Modbus Holding Register (R/W)	
Register Data-Address	**Description**
263	**Default alarm** 0: No alarm 1: Alarm

4.7 Set point

4.7.1 Overview

The active set point is determined by configuration of the time channels. The user can modify values in defined limits.
The Modbus type enables the option to configure the set point according to your needs and/or to indicate the set point from a supervisory system at runtime.

4.7.2 Holding Register

Set point after reset (Parameter)
After a restart of the device this value is used as a set point until a new set point or a Modbus default is activated.

Adjustment range of set point (Parameter)
Determines the limits of the set point adjustment range. When selecting the display of the set point adjustment (register 113) as stage display – 3…+3 this parameter must be set to the value of the set point offset of stage 3!
Example: Step size 1K => Stage 3 is equivalent to 3K => enter this value!! Take care of the scaling!

Set point step range (Parameter)
Determines the step size of the set point offset upon changes at the device by a user.

Dead band/Dead band ECO-mode (Parameter)
Determines the deadband in normal controller mode respectively in ECO-mode. For activation of the ECO-mode refer to chapter **Time Channels**.

Set point adjustment standby (Parameter)
When using the occupancy function by a digital input or via Modbus, the configured value is automatically deducted from the heating set point or added to the cooling set point in UNOCCUPIED state.
The Occupied / Eco override parameter can be used to parameterize how the occupancy state affects when the controller is in ECO mode. For further information, see Chap. Occupancy.

Frost Protection/Heating Protection (Parameter)
By use of the window function (energy hold off) through a digital input or via Modbus, in case "Window open/Energy hold off" the heating and cooling set points are set to the configured values.

Behavior of set point offset at occupancy change (Parameter)
Behavior of the set point offset value when occupancy state changes. Select whether the offset is (1) retained, (2) reset or (3) restored during occupancy state UNOCCUPIED. If set point offset value should be restored, value is set to zero during UNOCCPIED state and previous value is restored after switching to the OCCPUPIED state.

Basic Set point
This register is designed for the set point default by a supervisory system. Heating and cooling set point are calculated internally out of this value and the dead band depending on the mode (normal/ECO).

Set point Offset
External default for override of internal set point offset.

Modbus Holding Register (R/W)	
Register Data Address	**Description**
20	**(#) Set point after reset** 0,0 - 50,0°C *Default 21,0°C*
21	**(#) Adjustable range set point** 0-100 ≙ 0,0 - 10,0°C *Default: 3,0°C*
22	**(#) Set point step range** 0-100 ≙ 0,0 - 10,0°C *Default: 0,5°C*
23	**(#) Dead band** 0-150 ≙ 0,0 - 15,0°C *Default: 2,0°C*
24	**(#) Dead band ECO mode** 0-150 ≙ 0,0 - 15,0°C *Default: 10,0°C*
25	**(#) Set point adjustment standby** 0-150 ≙ 0,0 - 15,0°C *Default: 2,0°C*
26	**(#) Frost Protection** 0-150 ≙ 0,0 - 15,0°C *Default: 7,0°C*
27	**(#) Heat protection** 0-500 ≙ 0,0 - 50,0°C *Default: 35,0°C*

135	**(#)Behavior of set point offset at occupancy change** 0: Retain *(default)* 1: Reset 2: Reset during UNOCCPIED and restore after switching to OCCUPIED
255	**Basic set point** 0-500 ≙ 0,0 - 50,0°C *Default: 21,0°C*
256	**Set point offset** 0-150 ≙ 0,0 - 15,0°C *Default: 0°C*

The registers marked with # are saved in EEPROM. They shall be written only during configuration of the device and not at runtime!

4.7.3 Input Register

Set point heating
Output of active heating set point which depends on the default of basic set point (time channel/Modbus default), set point offset (user/Modbus) and mode (normal/ECO, occupied/unoccupied).
The value changed at last determines the set point, i.e. set point of the active time channel will be overwritten by an update of register *basic set point* (address 255) or if a new time channel is activated.

Set point cooling
Output of the active cooling which depends on the default of basic set point (time channel/Modbus default), set point offset (user/Modbus) and mode (normal/ECO, occupied/unoccupied).
The value changed at last determines the set point, i.e. set point of the active time channel will be overwritten by an update of register *basic set point* (address 255) or if a new time channel is activated.

Set point offset
Output of internal offset which is defined by user setting at JOY or via Modbus register 257. The value changed at last determines the set point. This means for example that a set point adjusted by user will be overwritten with the next update by register *Set point offset* (address 257).

Modbus Input Register (R)	
Register Data Address	**Description**
511	**Set point heating** 0-500 ≙ 0-50,0°C Example: 21,5°C = 215
512	**Set point cooling** 0-500 ≙ 0-50,0°C Example: 21,5°C = 215
513	**Set point offset** 0-500 ≙ 0-50,0°C Example: 21,5°C = 215

4.8 Fan coil stages

4.8.1 3 stages fan coil type (3 relays)

4.8.1.1 Overview

JOY comes with three outputs for control of up to three fan coil stages. Fan coil stage can be changed manually. The number of existing stages can be configured. The user can select between OFF, STAGE1, STAGE2, STAGE3 and AUTOMATIC operation. In automatic mode the fan coil stage is linked to the controller. The fan coil can be freely assigned to controller mode (enabled at (a) heating/cooling, (b) only heating or (c) only cooling).
To guarantee a save start-up of the fan, a period of time can be parameterized in which the fan starts with the highest possible stage available.
The function of the fan coil stage is determined during configuration of the time channels (see chapter **time channels**) per period. The user is able to override the time channel settings by manual operation. With start of the next time channel period the fan coil stage is set to the value configured in the period. In addition it is possible to override the stage via Modbus. With start of next time channel period the fan coil stage is set to the value configured in the period.
When using the occupancy option the fan stage is linked with occupancy state. In manual mode, fan is switched to automatic mode if occupancy state changes to UNOCCUPIED. Then set points of state UNOCCUPIED are valid. When returning to state OCCUPIED the automatic mode is set, activating set point values of state OCCUPIED.
Furthermore, it is possible to select whether the fan is coupled to the control of the heating/cooling output during PWM operation of the controller. In this case, the fan is only activated if the heating/cooling output is also controlled.
The on / off behavior of the stages depends on the operating mode of the active controller. If the controller operates as a two-point controller, the stages are switched as a function of the parameterized threshold values for the fan stages 1/2/3. In the case of the PI controller, the stages are output as a function of the actuating variable of the controller.

3 stages	2 stages	1 stage
Stage 3: y > 66%	-	-
Stage 2: y > 33%	Stage 2: y >= 50%	-
Stage 1: y > 0%	Stage 1: y > 0%	Stage 1: y > 0%

4.8.1.2 Holding Register

Treshold stage 1/2/3 (parameter)
The value configured determines the threshold between set and actual value at which the individual fan stages are switched on when controller is active. For example using the default setting (threshold value fan stage 1 = 0), fan stage 1 is started instantly if a control deviation occurs. It has to be considered that a hysteresis for the on/off switching of the fan stages is activated (+/-0.3°C) to prevent a flickering of the outputs!

Start-up time fan coil (parameter)
To guarantee a save start-up of the fan, a period of time can be configured in which the fan starts with the highest possible stage available.

Fan coil assignment (parameter)
Optionally, the fan can optionally be allocated to heating or cooling controller or to both at the same time.

Switch/control behavior fan stages (parameter)
Here you can choose whether the fan is connected to the state of the valve. When selecting dependent, the fan only runs if the heating or cooling valve is activated and the actuating variable has exceeded the parameter parameterized here. Example: Switching / control behavior = 20% => Fan runs with a actuating variable >20%. If Independent is selected, the fan runs continuously as long as the controller is in the heating or cooling mode (actuating variable> 0) regardless of whether the valve is activated.

Keys Fan stage with / without AUTO (parameter)
Select whether the user can only switch manual steps or addionally AUTOMATIC mode.

Modbus Holding Register (R/W)	
Register Data Address	**Description**
9	**(#)Number of fan coil stages** 1: 1 stage 2: 2 stages 3: 3 stages *(default)*
30	**(#) Treshold stage 1 ON** 0-150 ≙ 0,0 - 15,0°C *Default : 0,0°C*
31	**(#) Treshold stage 2 ON** 0-150 ≙ 0,0 - 15,0°C *Default :1,5°C*
32	**(#) Treshold stage 3 ON** 0-150 ≙ 0,0 - 15,0°C *Default : 3,0°C*
98	**(#)Fan coil assignment** 0: Heating/Cooling *(default)* 1: Heating 2: Cooling
113	**(#) Start-up time fan coil** 0-30s ≙ 0 – 300 *Default: 1s*
129	**(#) Switch/control behavior fan stages** -1: independent *(default)* 0-20 ≙ 0%-20%: dependent
134	**(#) Keys Fan stage with / without AUTO** 0: with AUTOMATIC *(default)* 1: without AUTOMATIC
270	**Fan coil stage** 0: Off 1: Stage 1 2: Stage 2 3: Stage 3 3: Automatic *(default)*

The registers marked with # are saved in EEPROM. They shall be written only during configuration of the device and not at runtime!

4.8.1.3 Input Register

Modbus Input Register (R)	
Register Data Address	**Description**
518	**State fan coil stage** $0x00_{hex}$: Off $0x01_{hex}$: Stage 1 $0x02_{hex}$: Stage 2 $0x03_{hex}$: Stage 3 -255 (=$0xFF01_{hex}$): Auto stage 1 -254 (=$0xFF02_{hex}$): Auto stage 2 -253 (=$0xFF03_{hex}$): Auto stage 3

4.8.2 EC-fan coil (0-10V)

4.8.2.1 Overview

A 0-10V output is implemented for control of an EC fan. The speed of the fan coil unit can be changed manually via the keys. The number of steps for changing the speed between 0 and 100% is configurable.
In automatic mode the fan coil stage is linked to the controller. The fan coil can be freely assigned to controller mode (enabled at (a) heating/cooling, (b) only heating or (c) only cooling).

When using a PI controller, the output value corresponds to the control variable of the controller, adapted to the number of stages of the fan control. With a 2-point controller the output value is also adapted to the number of stages of the fan control depending on the parameter *Maximum fan coil value (100%) at temperature deviation* (address 30).
To guarantee a reliable start-up of the fan coil unit, a period of time can be parameterized in which the fan starts with the highest possible stage available.

If time channels are used, the operation mode of fan coil unit is determined during configuration of the time channels (see chapter **Time channels**) per period. The user is able to override the time channel settings by manual operation. With start of the next time channel period the fan coil stage is set to the value configured in the period.
In addition, fan coil stage can be overridden via Modbus. With start of next time channel period the fan coil stage is set to the value configured in corresponding period.

When using the occupancy option the fan stage is linked with the occupancy state. In manual mode, fan is switched to automatic mode if occupancy state changes to UNOCCUPIED. Then, set points of state UNOCCUPIED are valid. When returning to state OCCUPIED, automatic mode is set activating set point values of state OCCUPIED.

The parameter *fan coil minimum* and *fan coil maximum* enable the option to adapt the fan speed individually to the control signal of the controller (0-100%), e.g. 20%-80% fan speed.

4.8.2.2 Holding Register

Maximum fan coil value (100%) at temperature deviation
If a two-point controller is activated the parameterized value is the deviation of set point from actual value at which the output of the fan coil unitl has reached 100%. Below this value the output value is calculated linear to the deviation and is output in the configured stages.

Fan coil assignment
Optionally, the fan can only be allocated to the heating/cooling controller or to both at the same time.

Steps fan coil control
Determines the number of steps and thus the step size of the fan stage control.

Fan coil minimum, Fan coil maximum
Minimum and maximum output value for fan control. The calculation of the stages is made between minimum and maximal value.
Special case:
When setting the most significant bit of the minimum value, the minimum value corresponds to stage 1. The step size of the control is calculated of the number of stages of the fan coil unit, the minimum and maximum.
Example:

Number of steps: 3
Minimum: 50%, Maximum:70%

⇨ OFF=0%, Stage1=50%, Stage2=60%, Stage3= 70%

Start-up-time fan coil
To guarantee a reliable start-up of the fan, a period of time can be parameterized in which the fan starts with the highest possible stage available.

Keys Fan stage with / without AUTO (parameter)
Select whether the user can only switch manual steps or addionally AUTOMATIC mode.

Switch/control behavior fan stages (parameter)
Here you can choose whether the fan is connected to the state of the valve. When selecting dependent, the fan only runs if the heating or cooling valve is activated and the actuating variable has exceeded the parameter parameterized here. Example: Switching / control behavior = 20% => Fan runs with a actuating variable >20%. If Independent is selected, the fan runs continuously as long as the controller is in the heating or cooling mode (actuating variable> 0) regardless of whether the valve is activated.

Default fan coil
Default of fan speed in percentage or toggling in automatic mode. It is converted corresponding to the parameter *steps fan coil control* to the matching step.
Example: Default: 65%, 3 fan coil stages at 33%, 66% and 100%=> Output 66%

Modbus Holding Register (R/W)	
Register Data Address	**Description**
30	**(#)Maximum fan coil value (100%) at temperature deviation** 0-150 ≙ 0,0 - 15,0°C *Default : 4,0°C*
98	**(#)Fan coil assignment** 0: heating/cooling *(default)* 1: heating 2: cooling
110	**(#)Steps fan coil control** 1: = 100% step 2: = 50% steps 3: = 33% steps 4: = 25% steps 5: = 20% steps *(default)*
111	**(#)Fan coil minimum** 0-100 ≙ 0-100% (0-10V) *Default : 0%* Special case $0x8xxx_{hex,}$ see **description: Fan coil minimum, Fan coil maximum**

112	**(#)Fan coil maximum** 0-100 ≙ 0-100% (0-10V) *Default: 100%*
113	**(#) Startup time fan coil** 0–300 ≙ 0 – 30s *Default: 1s*
129	**(#) Switch/control behavior fan stages** -1: independent *(default)* 0-20 ≙ 0%-20%: dependent
134	**(#) Keys Fan stage with / without AUTO** 0: with AUTOMATIC *(default)* 1: without AUTOMATIC
270	**Default fan coil** 0-100 ≙ 0-100% Manual -256 (=0xFF00$_{hex}$) = Automatic *Default: 0%*

The registers marked with # are saved in EEPROM. They shall be written only during configuration of the device and not at runtime!

4.8.2.3 Input Register

Modbus Input Register (R)	
Register Data Address	**Description**
518	**Fan coil value** 0-100% ≙ 0-100% Manual -256..-156 (=0xFF00$_{hex}$-0xFF64$_{hex}$): Automatic with value

4.9 Keycard Switch

If Keycard is not inserted the device is set into the ECO-mode. The operation of the keys is locked, display is switched-off and controller uses set points defaults of UNOCCUPIED-state (lowering set point heating by value of register *Set point adjustment standby* (address 25) and increase set point cooling accordingly). If a key-card switch is parameterized, function 'Switch device on/off' via keys or Modbus is locked.

4.10 Occupancy

4.10.1 Overview

A occupancy function is available, which, if activated, has a direct influence on the set point default of the controller.
The occupancy function can be activated via the configuration of a digital input. Further information can be obtained in the chapter **Inputs**. In addition or alternatively, the default can be set via Modbus. The default via Modbus has a higher priority than the internal state. The ON / OFF button on the device can also be configured as a occupancy key (see chapter 3.1.1). If the occupancy function is activated, the occupancy icon is automatically displayed when the occupancy symbol has been assigned a position in the footer. In state UNOCCUPIED, the heating setpoint is decreased by the value of the parameter *Set point adjustment standby* (address 25), the cooling setpoint is increased accordingly.

4.10.2 Holding Register

Occupied / ECO override (Parameter)
The occupancy state OCCUPIED may override an active ECO mode. The controller disables ECO mode and operates in OCCUPIED state as long as the occupancy state is OCCUPIED. By switching back to state UN-OCCUPIED, the ECO mode is restored.
In the other case, the occupancy state has no influence with the ECO mode active.

Default Occupancy
The symbol Occupied/Unoccupied is faded-in automatically if value OCCUPIED or UNOCCUPIED is written in register *Default Occupancy* (address 257) and the occupancy symbol is allocated to any position in the footer.

Modbus Holding Register (R/W)	
Register Data Address	**Description**
136	(**#) Occupied / ECO override** 0: Occupancy State does not override ECO mode *(default)* 1: OCUPIED state overrides ECO mode
257	**Default Occupancy** 0: Unoccupied 1: Occupied -1 ≙ 0xFFFF: No function (default)

4.10.3 Input Register

Modbus Input Register (R)	
Register Data Address	**Description**
521	**Occupancy state** 0: Room unoccupied 1: Room occupied -1 ≙ 0xFFFF: No function

4.11 Dewpoint

4.11.1 Overview

JOY implements a dewpoint function which has direct effect on the set point default of the controller if activated. An active dewpoint contact locks the cooling controller.
The dew point function is activated via one digital input or via Modbus. The default via Modbus is linked by an OR-function to internal state.
Detailed information to be found in chapter **Inputs**. With activated dewpoint function the dew point symbol “dewpoint active“ is faded-in automatically and cooling controller is locked.

4.11.2 Holding Register

Modbus Holding Register (R/W)	
Register Data Address	**Description**
258	Default dewpoint 0: Dewpoint inactive 1: Dewpoint active -1 ≙ 0xFFFF: No function *(default)*

4.11.3 Input Register

Modbus Input Register (R)	
Register Data Address	**Description**
522	State dewpoint 0: Dewpoint inactive 1: Dewpoint active -1 ≙ 0xFFFF: No function

4.12 Window Contact/Energy hold off

4.12.1 Overview

JOY comes with a window contact/energy lock function which, if activated, has direct effect on the set point of the controller. With triggered contact (window open = energy lock active) the set points for heating and cooling are automatically set to frost- respectively heat-protection. The fan state changes to the automatic mode and, after exiting the energy lock mode, resumes the previous state.
The window contact/energy lock function is activated via configuration of one digital input or via Modbus. The default via Modbus is linked by an OR-function to the internal state.
More information to be obtained in chapter **Inputs**. With activated window contact function (window is open) the symbol “window contact“ is faded-in automatically. Additionally frost- and heat protection are activated.

4.12.2 Holding Register

Modbus Holding Register (R/W)	
Register Data Address	**Description**
259	**Default window contact/ energy hold off** 0: Window closed 1: Window opened -1 ≙ 0xFFFF: No function *(default)*

4.12.3 Input Register

Modbus Input Register (R)	
Register Data Address	**Description**
523	**State window contact/energy hold off** 0: Window closed 1: Window opened -1 ≙ 0xFFFF: no function

4.13 Change-Over

4.13.1 Overview

The room thermostat has a change-over function which has, if activated, a direct effect on controller behaviour. Via a change-over contact the mode heating or cooling is pre-defined with a 2-pipe system.
The change-over function is activated via configuration of a digital input or via Modbus. An input activated as a change-over contact deactivates Modbus value (register 256). Detailed information can be obtained in chapter **Inputs**. Depending on the state of the contact, only the heating or only the cooling controller is activated. If the input is configured as a NO contact, the heating mode is enabled when the input is open and when the input closed, the cooling mode is enabled.
Note: Only output heating (clamp 5) is active, when using change-over.

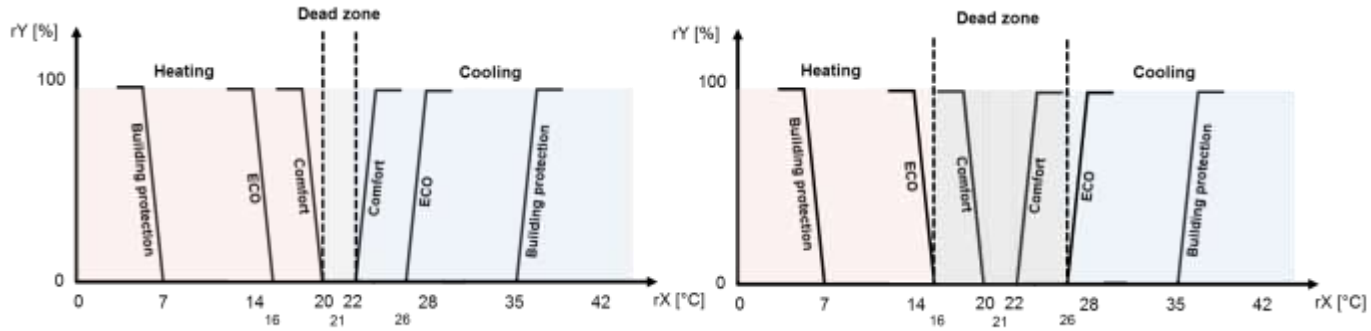
4.13.2 Holding Register

Modbus Holding Register (R/W)	
Register Data Address	**Description**
260	**Default change-over** 0: Mode heating 1: Mode cooling -1 ≙ 0xFFFF: No function

4.14 Controller

4.14.1 Overview

JOY comes with a PI- respectively two-point/three-point controller for heating and cooling. For heating and cooling, in addition to the parameters Proportional range Xp and Integral time Tn, it is possible to individually parameterize which controller type (PI / 2-point) is to be used and whether the controller is to be active.
Besides the activation of automatic modes, heating and cooling, output can be switched manually writing to register *Default controller mode* (address 269). In this case internal controller is deactivated, but the corresponding symbol is faded-in on screen. The control output is output via the two relay outputs for heating / cooling (PWM / 2-point).
In automatic operation the fan coil stages are linked with the controller. Further information to be found in chapter **fan coil stages**.



Picture 17: Two-step control with hysteresis

The set point defaults are determined by the active time channel or a Modbus default and in addition to the dependence of ambient parameters such as occupancy, window contact, dew point, ECO mode and the user-defined set point offset.
Controller starts with a 4 minute delay after power-up.

4.14.2 PI-controller

The time response of the PI-controller is determined with parameters Xp and Tn. Due to the proportional band, the control variable reacts instantly on the control difference while the integral portion is only occurring with the time of action. The resulting control variable is output as a pulse width modulated signal.

4.14.3 Two-point controller

If value goes below set point less hysteresis treshold, the controller switches-on the heating output. In case value exceeds set point plus hysteresis threshold, the controller switches-off the heating output. As for cooling, it acts accordingly.

4.14.4 Valve Protection Function

In order to guarantee that the valves are also fully functional when not in use for a longer period of time, the room thermostat has a valve protection function. The valve protection is only started, when corresponding valve (heating or cooling) has not been triggered for more than 96 hours. The time is fixed to Friday at 11:00am (heating valve) and 11:15am (cooling valve). The corresponding valve is switched on for 5 minutes.
The valve protection function can be disabled.

4.14.5 Holding Register

Controller Hysteresis
Determines the turn ON/OFF behaviour of the controller. The heating controller is switched ON if value falls below set point less half of the hysteresis and heats until actual value of set point plus half of hysteresis is exceeded. The hysteresis prevents the “flickering” of the actuator if actual value is within the value of set point.
Not used with PI-controller

Controller Mode after device reset
Determines the startup mode of controller after restart.

Treshold Value Fan coil stage 1/2/3 One
The parameterized value determines the threshold between the set point and the actual value at which the single fan coil stages are turned on. For example, fan coil stage 1 starts directly with the occurrence of a controller request at parameterized threshold = 0,0°C. Please note that there is an internal hysteresis of +/- 0.3°C active to avoid flickering of the outputs!
This parameter is only relevant if a two-point controller is used.

Valve Protection Release
Release/Lock of the valve protection

Proportional band Xp
The proportional band determines the deviation at which the controller outputs the maximum control variable (100%). A small Xp relates to a stronger controller intervention of the proportional band with lower deviations, but increases the tendency to oscillate.

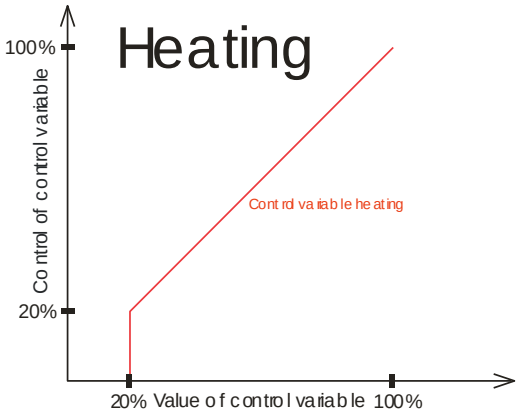
Reset time Tn
Time passing by until the Integral-part produces the same control amplitude as produced directly in case of the Proportional band. To increase the integral part of the controller the reset time must be reduced.

Minimum actuating variable
Minimum value in percent.

Maximum actuating variable
Maximum value in percent.

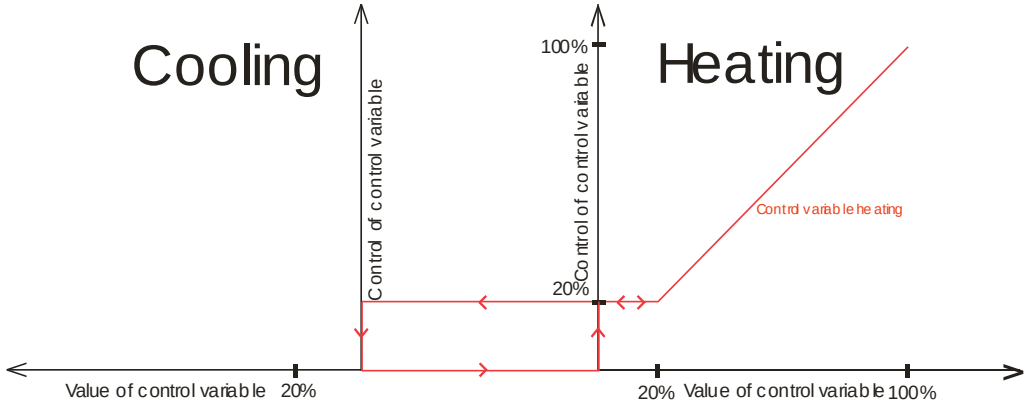
Mode Selection Control Variable

(1) Mode selection Control Variable = 1
Ymin = 20%



The control variable is only sent to the output if the calculated value of the control variable is bigger than the minimal control variable.

(2) Mode selection Control Variable = 0
Ymin = 20%



The minimal control variable at the output remains unchanged until the controller changes the operating mode

PWM cycle time
Cycle time of the PI-controller ouput signal.
The ON/OFF time of the digital outputs is calculated as a function of the actuating variable.
Example: PWM time = 30min, actuating variable y = 50% ⌊ T_{on} = 15min, T_{off} = 15min
Only relevant when using the PI controller and existing digital switching outputs (device types FC and HC).
Only relevant when using the PI-controller.

Heating controller type
Heating controller can be configured as PI- or Two-point-controller.

Cooling controller type
Cooling controller can be configured as PI- or Two-point-controller.

Effective direction of relay
Effective direction can be changed for the two relay heating and cooling to adapt to the existing actuator (normaly open or normaly closed).
Not for 3AO version!

Default Controller Mode
Default of controller mode. In automatic operation the controller controls to heating and cooling set point. 'Heating mode enabled' means that controller is in automatic heating mode with deactivated cooling controller and vice versa. Additionally it is possible to set heating and cooling output manually. If one of the outputs is set to manual mode the corresponding symbol in display is faded-in. Internal controller is deactivated.
Not for 3AO version!

Default output heating / cooling
The outputs are decoupled from the internal controller and can be controlled by the higher-level system. To display a symbol (heating / cooling) a the output, the manual mode must be activated (0xFF01 = Heating or 0xFF02 = Cooling) via Register data address *Default controller mode*.
Only for 3AO version!

Modbus Holding Register (R/W)	
Register Data Address	**Description**
28	**(#) Controller hysteresis** 0-150 ≙ 0,0 - 15,0°C *Default: 1,0°C*
29	**(#) Controller Mode after device reset** 0: Off 1: Heating 2: Cooling 3: Auto *(default)* 17 (=0x11$_{hex}$): Heating mode (auto) triggering heat and cool relay/output 18 (=0x12$_{hex}$): Cooling mode (auto) triggering heat and cool relay/output
33	**(#)Valve protection release** 0: Lock 1: Release *(default)*
102	**(#) Proportional band Xp heating** 0-100 ≙ 0,0 - 10,0°C *Default: 2,0°C*
103	**(#) Reset time Tn heating** 0-1000 ≙ 0-1000min *Default: 30m*
104	**(#) Minimum actuating variable heating** 0-100 ≙ 0–100% *Default: 0%*

105	**(#) Maximum actuating variable heating** 0-100 ≙ 0–100% *Default: 100%*
106	**(#) Mode Selection Control Variable** 0: Use Minimal Control Variable with control variable = 0 *(default)* 1: Use Minimal Control Variable with control variable > 0
107	***(#) PWM cycle time*** 5-60 ≙ 5 – 60min *Default: 30min*
108	**(#) Heating controller type** 0: PI-controller *(default)* 1: Two-point controller
109	**(#) Cooling controller type** 0: PI-controller *(default)* 1: Two-point controller
125	**(#) Proportional band Xp cooling** 0-100 ≙ 0,0 - 10,0°C *Default: 2,0°C*
126	**(#) Reset time Tn cooling** 0-1000 ≙ 0-1000min *Default: 30m*
127	**(#) Minimum actuating variable cooling** 0-100 ≙ 0–100% *Default: 0%*
128	**(#) Maximum actuating variable cooling** 0-100 ≙ 0–100% *Default: 100%*
132	**(#)Effective direction of heating output** 0: Make contact (default) 1: Break contact
133	**(#)Effective direction of cooling output** 0: Make contact (default) 1: Break contact
269	**Default controller mode** 0: Off 1: Heating mode enabled (auto) 2: Cooling mode enabled (auto) 3: Auto mode *(default)* 17 (=0x11$_{hex}$): Heating mode (auto) triggering heat and cool relay/output 18 (=0x12$_{hex}$): Cooling mode (auto) triggering heat and cool relay/output -255 (=0xFF01$_{hex}$): Set heating output (manual mode) -254 (=0xFF02$_{hex}$): Set cooling output (manual mode) -239 (=0xFF11$_{hex}$): Heating mode (manual) triggering heat and cool relay/output -238 (=0xFF12$_{hex}$): Cooling mode (manual) triggering heat and cool relay/output
271	**Default output heating** Device type Fancoil_3AO: 0-100 (=0x00-0x64) = 0-10V in manual mode, no symbol 65535 (=0xFFFF): output will be controlled internally *(default)*
272	**Default output cooling** Device type Fancoil_3AO: 0-100 (=0x00-0x64) = 0-10V in manual mode, no symbol 65535 (=0xFFFF): output will be controlled internally *(default)*

The registers marked with # are saved in EEPROM. They shall be written only during configuration of the device and not at runtime!

4.14.5.1 Input Register

Modbus Input Register (R)	
Register Data Address	**Description**
516	**Output heating** Device type Fancoil and Fancoil_EC: 0: Off 1: On Device type Fancoil_3AO: 0-100 (=0x00-0x64) = 0-10V
517	**Output cooling** Device type Fancoil and Fancoil_EC: 0: Off 1: On Device type Fancoil_3AO: 0-100 (=0x00-0x64) = 0-10V
524	**Actuating variable controller** 0-100 (=0x00-0x64) ≙ 0-10V
525	**Controller mode feedback** 0: Off 1: Heating 2: Cooling

5 Modbus Register Reference

All registers are of the type Signed 16 Bit! Specified is the protocol address. Register number is protocol address + 1!

5.1 3 stages fan coil type (3 relays)

5.1.1 Holding Register

Modbus Holding Register (R/W)	
Register Data Address	**Description**
0	(#)
1	(#)
2	(#) Device location recognition
3	(#) Language
4	(#) Offset internal sensor
5	(#) Offset external sensor
6	(#) Unit temperature
7	(#) Format time
8	(#) Format date
9	(#) Number of fan coil stages
10	(#) Display main screen
11	(#) Footer symbol 1
12	(#) Footer symbol 2
13	(#) Footer symbol 3
14	(#) Footer symbol 4
15	(#) Footer symbol 5
16	(#) Brightness background illumination LCD
17	(#) Brightness ring
18	(#) Input 1 universal input
19	(#) Input 2 230V input
20	(#) Set point after reset
21	(#) Set point adjustment
22	(#) Set point stepping
23	(#) Deadband
24	(#) Deadband ECO mode
25	(#) Set point adjustment standby
26	(#) Frost protection
27	(#) Heating protection
28	(#) Controller hysteresis
29	(#) Controller mode after device restart
30	(#) Threshold fan coil stage 1 On
31	(#) Threshold fan state 2 On
32	(#) Threshold fan coil stage 3 On
33	(#) Release valve protection
34	(#) Time channel 1 weekday
35	(#) Time channel 1 start time hour period 1
36	(#) Time channel 1 start time minute period 1
37	(#) Time channel 1 set point period 1
38	(#) Time channel 1 fan coil stage period 1
39	(#) Time channel 1 ECO mode period 1

40	(#) Time channel 1 start time hour period 2
41	(#) Time channel 1 start time minute period 2
42	(#) Time channel 1 set point period 2
43	(#) Time channel 1 fan coil stage period 2
44	(#) Time channel 1 ECO Mode period 1
45	(#) Time channel 1 start time hour period 3
46	(#) Time channel 1 start time minute period 3
47	(#) Time channel 1 set point period 3
48	(#) Time channel 1 fan coil stage period 3
49	(#) Time channel 1 ECO mode period 3
50	(#) Time channel 1 start time hour period 4
51	(#) Time channel 1 start time minute period 4
52	(#) Time channel 1 set point period 4
53	(#) Time channel 1 fan coil stage period 4
54	(#) Time channel 1 ECO mode period 4
55	(#) Time channel 2 weekdays
56	(#) Time channel 2 start time hour period 1
57	(#) Time channel 2 start time minute period 1
58	(#) Time channel 2 set point period 1
59	(#) Time channel 2 fan coil stage period 1
60	(#) Time channel 2 ECO mode period 1
61	(#) Time channel 2 start time hour period 2
62	(#) Time channel 2 start time minute period 2
63	(#) Time channel 2 set point period 2
64	(#) Time channel 2 fan coil stage period 2
65	(#) Time channel 2 ECO mode period 1
66	(#) Time channel 2 start time hour period 3
67	(#) Time channel 2 start time minute period 3
68	(#) Time channel 2 set point period 3
69	(#) Time channel 2 fan coil stage period 3
70	(#) Time channel 2 ECO mode period 3
71	(#) Time channel 2 start time hour period 4
72	(#) Time channel 2 start time minute period 4
73	(#) Time channel 2 set point period 4
74	(#) Time channel 2 fan coil stage period 4
75	(#) Time channel 2 ECO mode period 4
76	(#) Time channel 3 weekdays
77	(#) Time channel 3 start time hour period 1
78	(#) Time channel 3 start time minute period 1
79	(#) Time channel 3 set point period 1
80	(#) Time channel 3 fan coil stage period 1
81	(#) Time channel 3 ECO mode period 1
82	(#) Time channel 3 start time hour period 2
83	(#) Time channel 3 start time minute period 2
84	(#) Time channel 3 set point period 2
85	(#) Time channel 3 fan coil stage period 2
86	(#) Time channel 3 ECO mode period 1
87	(#) Time channel 3 start time hour period 3
88	(#) Time channel 3 start time minute period 3
89	(#) Time channel 3 set point period 3
90	(#) Time channel 3 fan coil stage period 3
91	(#) Time channel 3 ECO mode period 3
92	(#) Time channel 3 start time hour period 4
93	(#) Time channel 3 start time minute period 4

94	(#) Time channel 3 set point period 4
95	(#) Time channel 3 fan coil stage period 4
96	(#) Time channel 3 ECO mode period 4
97	(#) Daylight saving
98	(#) Fan coil assignment
99	(#) Max heating load
100	(#) Max cooling load
101	(#)
102	(#) Proportional band Xp
103	(#) Reset time Tn
104	(#) Minimum actuating variable
105	(#) Maximum actuating variable
106	(#)Mode Selection Control Variable
107	(#) PWM cycle time
108	(#)Heating controller type
109	(#)Cooling controller type
110	(#)
111	(#)
112	(#)
113	(#) Startup-time fan coil
114	(#) Display set point adjustment
115	(#) Special function key ON/OFF
116	(#) reserved
117	(#) reserved
118	(#) reserved
119	(#) reserved
120	(#) reserved
121	(#) reserved
122	(#) reserved
123	(#) reserved
124	(#) Lock parameter menu
125	(#) Proportional band Xp cooling
126	(#) Reset time Tn cooling
127	(#) Minimum actuating variable cooling
128	(#) Maximum actuating variable cooling
129	(#) Switch/control behavior fan stages
130	(#) Device state after reset
131	(#) Device values after reset
132	(#) Effective direction of output heating
133	(#) Effective direction of output cooling
134	
135	(#) Behavior setpoint offset
136	(#) Occupied- / ECO-override
Register Data Address	**Description**
255	Basic set point
256	Set point offset
257	Default presence
258	Default dew point
259	Default window contact/energy hold off
260	Default change-over
261	Device On/Off
262	Release keys

263	Default alarm
264	Time hour
265	Time minute
266	Date day
267	Date month
268	Date year
269	Default controller
270	Fan coil stage

The registers marked with # are saved in EEPROM. They shall be written only during configuration of the device and not at runtime!

5.2 Input Register

Modbus Input Register (R)	
Register Data Address	**Description**
511	Set point heating
512	Set point cooling
513	Set point offset
514	Internal temperature sensor
515	External temperature sensor
516	Output heating
517	Output cooling
518	State fan coil stage
519	State input 1
520	State input 2
521	State presence
522	State dew point
523	State window contact/energy off
524	Actuating variable controller
525	Controller mode feedback

5.3 EC- fan coil type (0-10V)

5.3.1 Holding Register

Modbus Holding Register (R/W)	
Register Data Address	**Description**
0	(#)
1	(#)
2	(#) Device location recognition
3	(#) Language
4	(#) Offset internal sensor
5	(#) Offset external sensor
6	(#) Unit temperature
7	(#) Format time
8	(#) Format date
9	
10	(#) Display main screen
11	(#) Footer symbol 1
12	(#) Footer symbol 2
13	(#) Footer symbol 3
14	(#) Footer symbol 4
15	(#) Footer symbol 5
16	(#) Brightness background illumination LCD
17	(#) Brightness ring
18	(#) Input 1 universal input
19	(#) Input 2 230V input
20	(#) Set point after reset
21	(#) Set point adjustment
22	(#) Set point stepping
23	(#) Deadband
24	(#) Deadband ECO mode
25	(#) Set point adjustment standby
26	(#) Frost protection
27	(#) Heating protection
28	(#) Controller hysteresis
29	(#) Controller mode after device restart
30	(#)Maximum fan coil value (100%) at temperature deviation
31	
32	
33	(#) Release valve protection
34	(#) Time channel 1 weekday
35	(#) Time channel 1 start time hour period 1
36	(#) Time channel 1 start time minute period 1
37	(#) Time channel 1 set point period 1
38	(#) Time channel 1 fan coil stage period 1
39	(#) Time channel 1 ECO mode period 1
40	(#) Time channel 1 start time hour period 2
41	(#) Time channel 1 start time minute period 2
42	(#) Time channel 1 set point period 2
43	(#) Time channel 1 fan coil stage period 2
44	(#) Time channel 1 ECO Mode period 1

45	(#) Time channel 1 start time hour period 3
46	(#) Time channel 1 start time minute period 3
47	(#) Time channel 1 set point period 3
48	(#) Time channel 1 fan coil stage period 3
49	(#) Time channel 1 ECO mode period 3
50	(#) Time channel 1 start time hour period 4
51	(#) Time channel 1 start time minute period 4
52	(#) Time channel 1 set point period 4
53	(#) Time channel 1 fan coil stage period 4
54	(#) Time channel 1 ECO mode period 4
55	(#) Time channel 2 weekdays
56	(#) Time channel 2 start time hour period 1
57	(#) Time channel 2 start time minute period 1
58	(#) Time channel 2 set point period 1
59	(#) Time channel 2 fan coil stage period 1
60	(#) Time channel 2 ECO mode period 1
61	(#) Time channel 2 start time hour period 2
62	(#) Time channel 2 start time minute period 2
63	(#) Time channel 2 set point period 2
64	(#) Time channel 2 fan coil stage period 2
65	(#) Time channel 2 ECO mode period 1
66	(#) Time channel 2 start time hour period 3
67	(#) Time channel 2 start time minute period 3
68	(#) Time channel 2 set point period 3
69	(#) Time channel 2 fan coil stage period 3
70	(#) Time channel 2 ECO mode period 3
71	(#) Time channel 2 start time hour period 4
72	(#) Time channel 2 start time minute period 4
73	(#) Time channel 2 set point period 4
74	(#) Time channel 2 fan coil stage period 4
75	(#) Time channel 2 ECO mode period 4
76	(#) Time channel 3 weekdays
77	(#) Time channel 3 start time hour period 1
78	(#) Time channel 3 start time minute period 1
79	(#) Time channel 3 set point period 1
80	(#) Time channel 3 fan coil stage period 1
81	(#) Time channel 3 ECO mode period 1
82	(#) Time channel 3 start time hour period 2
83	(#) Time channel 3 start time minute period 2
84	(#) Time channel 3 set point period 2
85	(#) Time channel 3 fan coil stage period 2
86	(#) Time channel 3 ECO mode period 1
87	(#) Time channel 3 start time hour period 3
88	(#) Time channel 3 start time minute period 3
89	(#) Time channel 3 set point period 3
90	(#) Time channel 3 fan coil stage period 3
91	(#) Time channel 3 ECO mode period 3
92	(#) Time channel 3 start time hour period 4
93	(#) Time channel 3 start time minute period 4
94	(#) Time channel 3 set point period 4
95	(#) Time channel 3 fan coil stage period 4
96	(#) Time channel 3 ECO mode period 4
97	(#) Daylight saving
98	(#) Fan coil assignment

99	(#) Max heating load
100	(#) Max cooling load
101	(#)
102	(#) Proportional band Xp
103	(#) Reset time Tn
104	(#) Minimum actuating variable
105	(#) Maximum actuating variable
106	(#)Mode Selection Control Variable
107	(#) PWM cycle time
108	(#) Heating controller type
109	(#) Cooling controller type
110	(#) Steps fan coil control
111	(#) Fan coil minimum
112	(#) Fan coil maximum
113	(#) Startup-time fan coil
114	(#) Display set point adjustment
115	(#) Special function key ON/OFF
116	(#) reserved
117	(#) reserved
118	(#) reserved
119	(#) reserved
120	(#) reserved
121	(#) reserved
122	(#) reserved
123	(#) reserved
124	(#) Lock parameter menu
125	(#) Proportional band Xp cooling
126	(#) Reset time Tn cooling
127	(#) Minimum actuating variable cooling
128	(#) Maximum actuating variable cooling
129	(#) Switch/control behavior fan stages
130	(#) Device state after reset
131	(#) Device values after reset
132	(#) Effective direction of output heating
133	(#) Effective direction of output cooling
134	
135	(#) Behavior setpoint offset
136	(#) Occupied- / ECO-override
Register Data Address	**Description**
255	Basic set point
256	Set point offset
257	Default presence
258	Default dew point
259	Default window contact/energy lock
260	Default change-over
261	Device On/Off
262	Release keys
263	Default alarm
264	Time hour
265	Time minute
266	Date day
267	Date month

268	Date year
269	Default controller
270	Fan coil stage

The registers marked with # are saved in EEPROM. They shall be written only during configuration of the device and not at runtime!

5.4 Input Register

Modbus Input Register (R)	
Register Data Address	**Description**
511	Set point heating
512	Set point cooling
513	Set point offset
514	Internal temperature sensor
515	External temperature sensor
516	Output heating
517	Output cooling
518	State fan coil stage
519	State input 1
520	State input 2
521	State presence
522	State dew point
523	State window contact/energy hold off
524	Actuating variable controller
525	Controller mode feedback

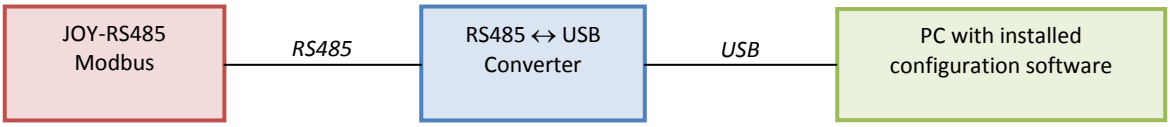
6 Configuration software

Download the latest version of the Thermokon configuration software from our website **www.thermokon.de**

Via the configuration software various device settings can be easily managed by a graphical surface. Created parameter files for the different available device types (3DI and Modbus) can be stored on SD card and transferred to the device. Therefore the front part has to be removed, SD card has to be inserted (card slot on front part!) and front part plugged on again. Subsequently device restarts, reads the parameter file from the card and stores the file. Don´t forget to remove the SD card!! Devices with intergrated Modbus-interface can also be configured by using the Modbus interface.

6.1 Connection to the PC

For connection of the JOY-RS485 Modbus and the PC an USB to RS485 Converter is needed.



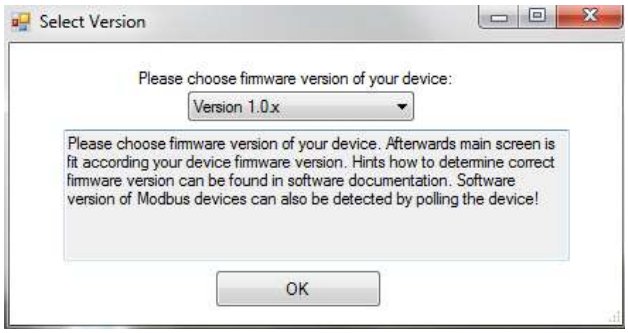
Further details can be obtained from the documentation of the corresponding converter.

6.2 Start screen

After launching configuration software start screen appears. Device model and language can be chosen.

6.3 Determine firmware version

There are different parameters for various firmware versions. To have the corresponding configuration screen indicated, the firmware version that fits device firmware must be selected before main screen is faded-in.



Picture 18: Determine device firmware version

As of version 1.3.0. the firmware version can be read out in the JOY display by means of the ON/OFF button. Device must be switched-off first and switched-on again afterwards. Then, the start screen is faded-in for approx. 5 seconds. Among others, the version number is indicated.
Devices with older versions must be restarted to show start screen.

For Modbus type, it is sufficient to only poll the device once (Button "Poll"). The software version is traced automatically and configuration screens are adapted accordingly. Polling must be made before changing any parameters!

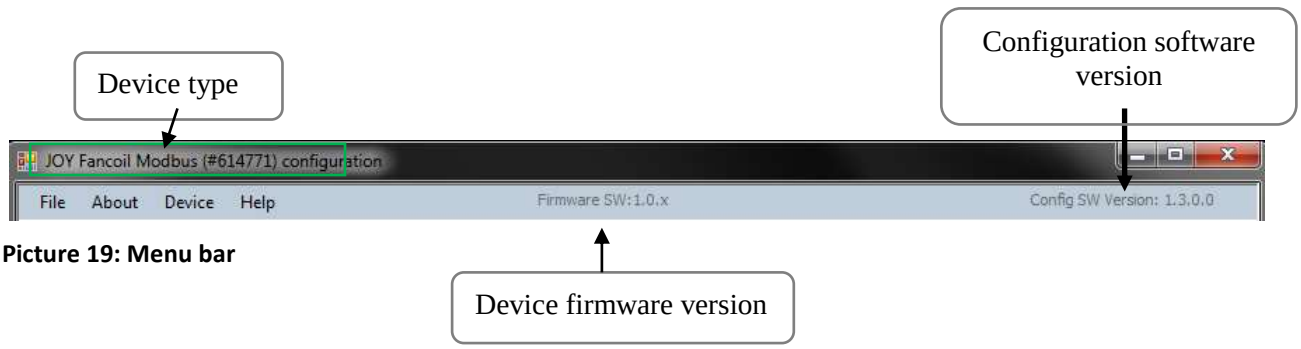
Devices from firmware version 1.3.0++ indicate on start screen if an invalid parameter file is found on plugged-in SD card!

6.4 Overview

6.4.1 Menu bar

Besides the further possibilities on loading/saving of parameters described below and the change of device types, the menu bar indicates the current device type sett, the firmware version of the device as well as the version of the configuration software.

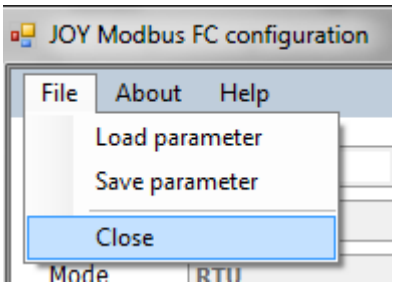
.



Picture 19: Menu bar

6.4.2 Parameter load/save

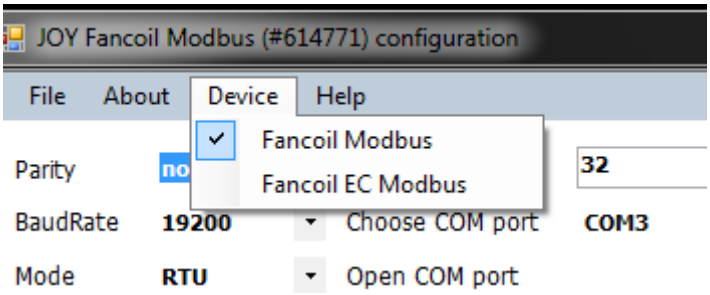
In menu bar an item "File" including sub items "Load parameter" and "Save parameter" can be found. A configuration file can be used for configuration of a device by means of a SD card. For more information see chapter SD Card. The configuration files are stored under name *confJoy.csv,* so that a JOY recognizes the file on SD card as a valid configuration file!



Picture 20: Menu bar

6.4.3 Device

Choose between different device types.

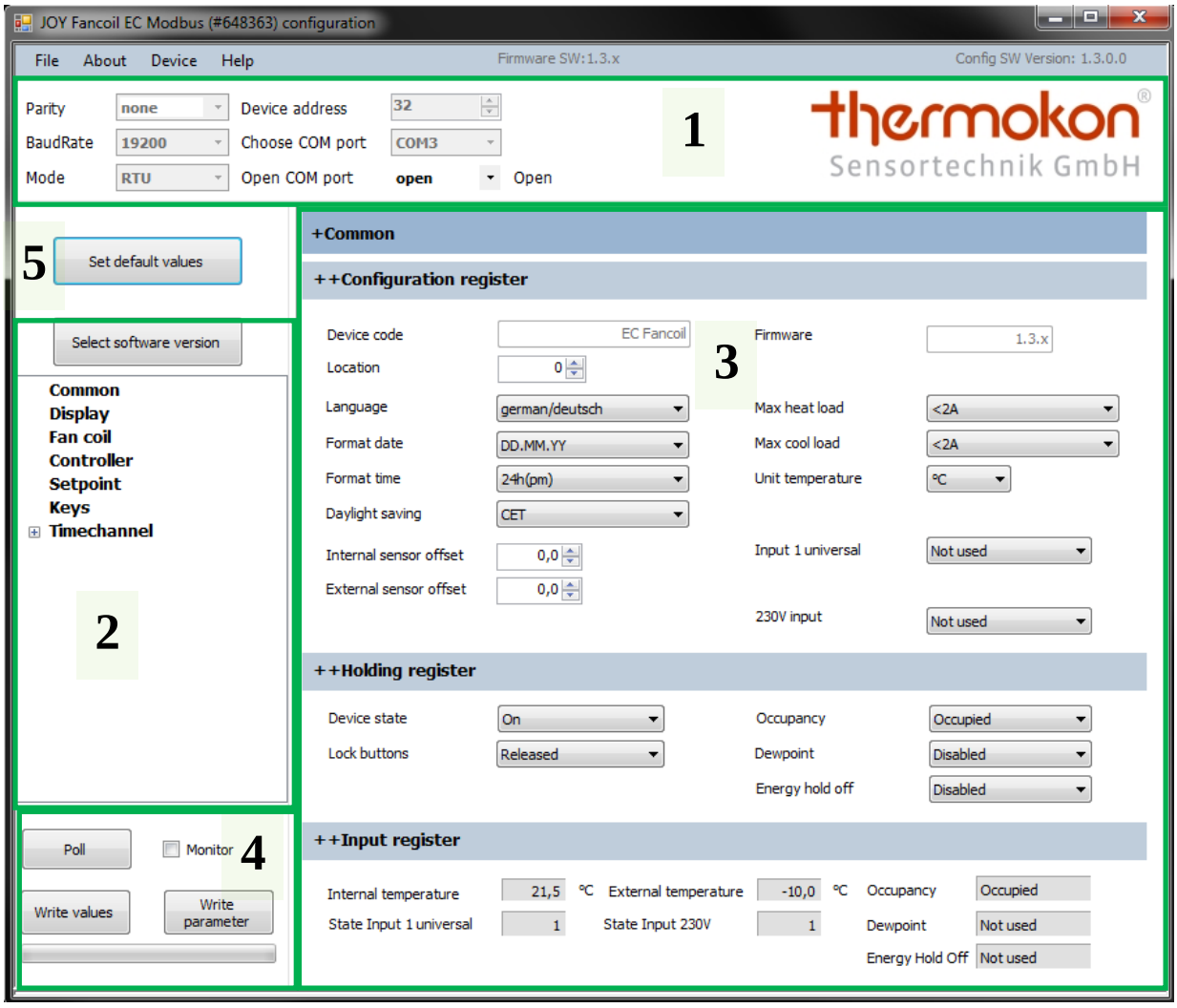


Picture 21: Change device type

If the configuration software discovers a discrepancy between user set device type and current device type during the polling teh device (Modbus), the user is asked to check the device type, accordingly!

6.4.4 Main screen

Following the main screen appears. The main screen is divided into five areas plus menu bar.



Picture 22: Change device type

1	Interface settings for modbus
2	Selection of device functions. In main window (3) the corresponding process data/parameters are displayed.
3	Main window with changeable parameters - Configuration register: Parameters to be saved in EEPROM - Input register: Process data (Modbus Holding Register) - Output register: Process data (Modbus Input Register)
4	Buttons for Modbus actions - Read out: Single device polling - Monitor: Continuous device polling - Write values: The values mentioned under point "Holding Register“ are written in the device. - Write parameter: The values mentioned under point "Configuration Register" are written in the device and are saved in EEPROM.
5	Set default values - All fields will be set to default values

The windows 1 and 4 are faded out for types without Modbus.

6.5 Appendix

6.6 Supported Control Commands

The following MODBUS control commands are supported by JOY:

Description	Function Code	
Read Holding Register	03 (hex)	3 (dez)
Read Input Register	04 (hex)	4 (dez)
Write multiple registers	10 (hex)	16 (dez)

Table 1 Supported Modbus Commands

6.7 Data Transmission

6.7.1 Master/Slave Protocol

One Master and one or more slaves are connected to the serial bus. Communication between Master and Salve is solely regulated by the Master. The Slaves are only allowed to transmit if they were addressed by the Master before. Slaves are only transmitting back to the Master, never to another slave.

6.7.2 Data Frame

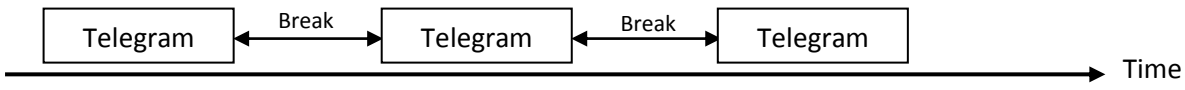
Data packets are transmitted according to strictly defined defaults:

Address	Control Command	Data	Checksum

In general a MODBUS telegram is started with the address of the slave, following a control command (e.g. read out registers) and the data. By means of the checksum at the telegram-end the bus participants can recognize transmission errors.

6.7.3 Transmission Mode RTU

In transmission mode RTU telegrams are separated from each other by means of transmission breaks.



The time of the transmission breaks for the separation of telegrams is depending on the adjusted baud rate and amounts to 3,5 * Word-Transmission Time (11 Bit). With 9600 baud at least 4ms and with 19200 baud at least 2ms between both telegrams must pass by.

6.7.3.1 Telegram Structure

Address 1 Byte	Control Command 1 Byte	Data 0 - 100 Byte	Checksum	
			Low	High

6.7.3.2 Calculation of CRC-Checksum

The CRC–checksum (Cyclical Redundancy Check) is calculated by the sender from all bytes transmitted and attached to the message. The receiver calculates the CRC checksum again and compares the same with the checksum received. If values do not match, a transmission error is assumed and the received data packet is rejected. The low-order byte of the 16 bit checksum is sent in the telegram at the next to last position and the high-order byte at last position.

Calculation of checksum (programming example in C):

```
crc = 0xFFFF;                                   // CRC-Check, Init
for(i = 0; i < telegram_length-2; i++)
        crc = crc_calc(crc, telegram_data[i]);

crc_low  = crc & 0x00FF;                        // Low-Byte
crc_high = (crc & 0xFF00) >> 8;         // High-Byte

// Calculate CRC
unsigned int crc_calc(unsigned int crc_temp, unsigned int data)
{
        unsigned int    Index_CC=0;
        unsigned int    LSB=0;
        crc_temp = ( ( crc_temp ^ data) | 0xFF00) & (crc_temp | 0x00FF) ;
        for(Index_CC = 0; Index_CC<8; Index_CC++)
        {
                LSB = (crc_temp & 0x0001);
                crc_temp   >>= 1;
                if(LSB)
                crc_temp = crc_temp ^ 0xA001; // calculation polynominal for CRC16
        }
        return(crc_temp);
}
```