thermokon
Sensortechnik GmbH

Interface Description

for

WRF04-RS485-Modbus

and

(LCN) FTW04-RS485-Modbus

1 Index of Changes

Version	Date	Description
A	09.02.2009	First Draft
B	04.03..2009	Type 2V added
C	18.08.2010	Fixed translation
D	06.12.2010	Changes in manual output mode valid since firmware version 1.08, configuration software since version 1.2
E	28.11.2011	6-way valve control added valid since firmware version 1.09, configuration software since version 1.3
F	14.05.2012	Corrections
G	18.02.2013	Corrections
H	22.08.2013	Documentation for (LCN) FTW04 included Optimized register description
I	21.05.2014	Description for 6-way valve modified (from firmware 1.11 and configuration software 1.6 or higher)
J	10.06.2015	Corrections
L	10.02.2017	Added description for device type SAUTER 6WV DN15 and DN20 Default values after communication failure Manual setting of output values without configuration bit activation (from Firmware 1.13 and configuration software 1.8 or higher) Optional address extension
M	25.11.2019	Corrections

2 Index

3 WRF04-RS485-Modbus & (LCN) FTW04-RS485-Modbus

The present document describes the serial interface of the room operating unit WRF04-RS485-MODBUS & (LCN) FTW04-RS485-Modbus. The MODBUS-Protocol developed by the comany Modicon is a disclosed protocol for communication of several intelligent Master-Slave based devices.

For further information and definitions on the topic MODBUS, please see www.modbus.org

3.1 Controller

3.1.1 Device Types

The PI-controller is integrated in the following devices: AO2V, OVR, OVT, DO2R, DO2T, 6WV (Belimo/Sauter).

3.1.2 Function Mode of PI-Controller

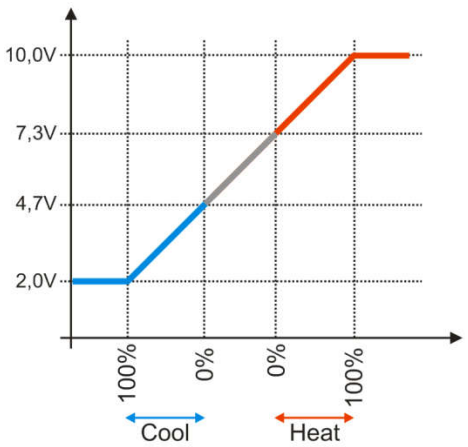
The integrated PI-controller controls the temperature (register 0x0102) of set point 1 (Register 0x0104). The control variable resulting is directly output to the outputs. The PI-controller can be set by properties. The control variable of the controller is re-calculated approx. every 10 seconds. Thus, changes, such as e.g. adjustment of set point or triggering of window contact are only considered after expiration of one controller interval.

3.1.3 Change-Over Operation

The device can be used for a 2-pipe and a 4-pipe wire system. The corresponding selection is made via the configuration coil “Change-Over Operation“. If the change-over operation is activated, the corresponding mode (heating or cooling of controller) must be defined (register 0x205, Controller mode). The **Change-Over Operation runs via output 1!**

3.1.4 Control 6-way valve

If device type BELIMO® 6-way valve is enabled, output AO2 is used as control variable output for 6-way valve. Control variable is calculated by integrated PI controller and the output voltage is adapted according to characteristic curve of used device type. Choosing type _INV inverts sequences for heating and cooling. Additionally control variable is output on AO1 adapted to 0-10V (= 0-100%).



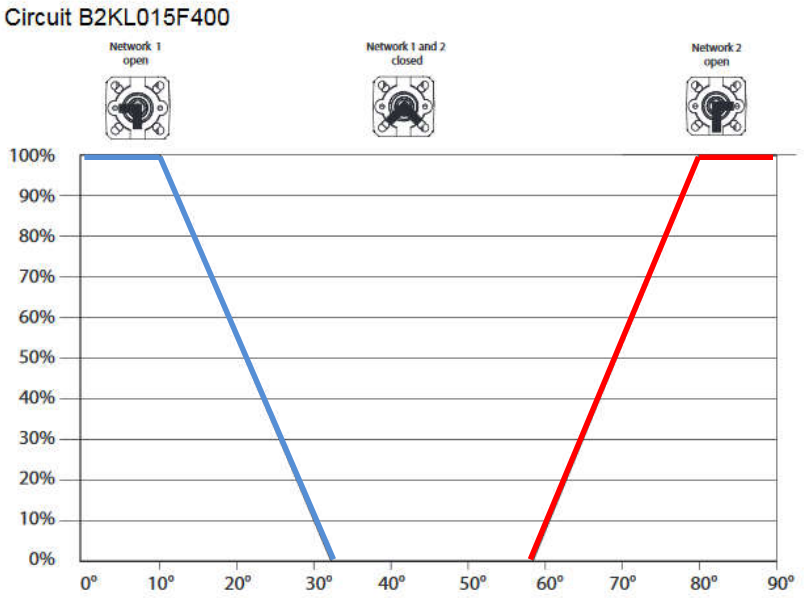
Type: 6WV
100…0% cooling ⇒ 2,0…4,7V
0…100% heating ⇒ 7,3…10,0V

Type: 6WV_INV
heating cooling sequences inverted

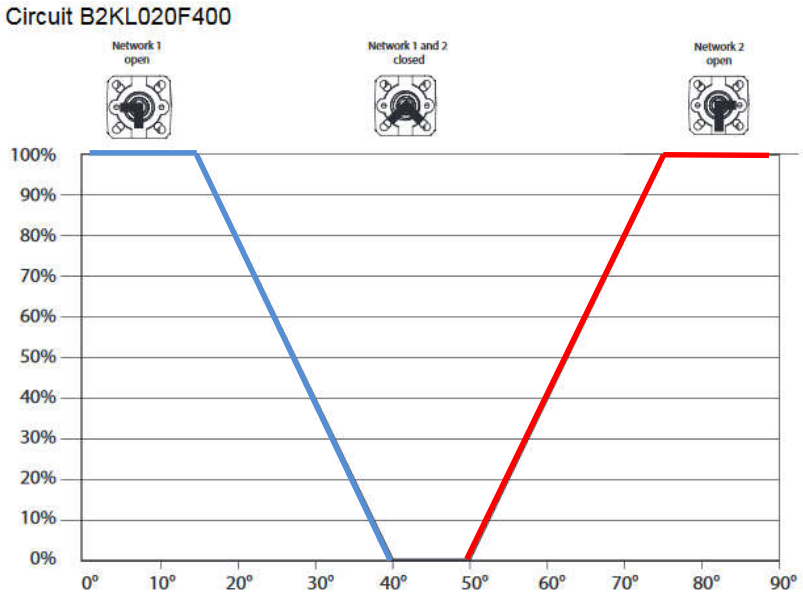
3.1.5 Function 6WV for SAUTER 6-way valves DN15 und DN20

If device type SAUTER 6-way valves is enabled, output AO2 is used as control variable output for 6-way valve. Control variable is calculated by integrated PI controller and the output voltage is adapted according to characteristic curve of used device type. Please see SAUTER datasheet 58.001, B2KL: 6-way-ball valve with male thread, PN16). Additionally control variable is output on AO1 adapted to 0-10V (= 0-100%).

Note: The 6WV-function is only available on device type AO2V.



Picture 1 Charactersitic curve of DN15 valve (extract from SAUTER datasheet 58.001e)



Picture 2 Charactersitic curve of DN20 valve (extract from SAUTER datasheet 58.001e)

3.1.6 Communication failure monitoring

The device monitors Modbus communication. In case of a 90s communication failure the outputs are set to default values, which can be configured in registers 38 and 39.
Setting -1 (=0xFFFF) as default value, the outputs keep their last values (manual mode) respectively the controller triggers them (automatic mode).

3.1.7 Energy Stop / Dew Point Detector

If a window contact or a dew point detector are connected to the digital inputs and the digital inputs are parameterized the same, both are directly affecting the control.

3.1.8 Override of Outputs

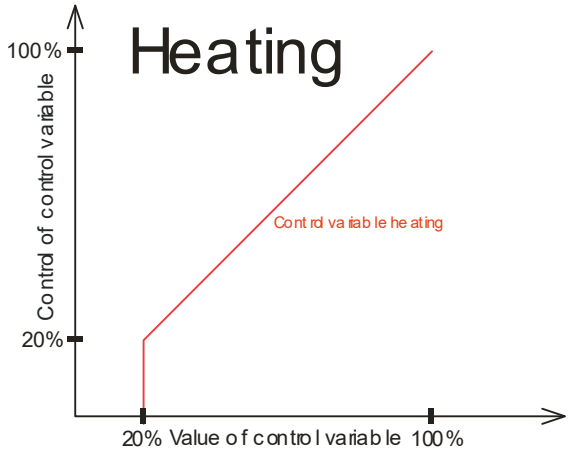
The outputs can be affected and overwritten directly by a master device. In the configuration registers 0x0001E and 0x001D the requested start values for the outputs are parameterized. During operation an overriding of the outputs is possible via the input registers 0x0206 and 0x0207.

3.1.9 Minimal Control Variable

By means of the property “Use minimal control variable with control variable = 0“(Coil-Bit 8 = 0) the minimal control variable is only used, if the control variable is > 0. If Coil-Bit 8 is =1, the minimal control variable is also used if the control variable is = 0.

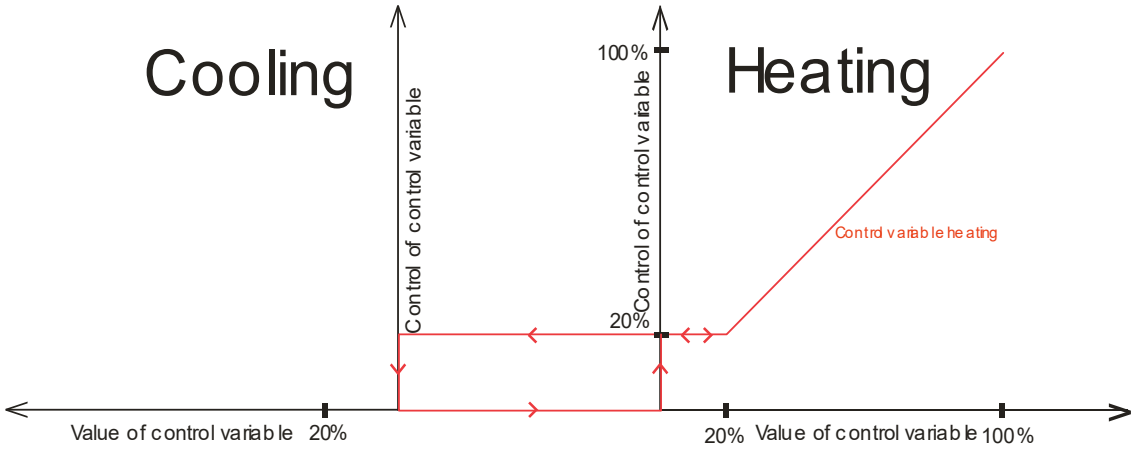
Mode Selection Control Variable (Register 0x0008)

(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

3.1.10 Determination of Set Points:

(1) OCCUPIED

- *Heating set point* =basic set point + offset(Adr. 0x0202) + poti offset*
- *Cooling set point* = basic set point + dead zone (Adr.0x000E) + offset(Adr. 0x0202) + Poti-Offset*

(2) UNOCCUPIED

- *Heating set point* = basic set point + offset(Adr. 0x0202) + poti offset* -night lowering
- *Cooling set point* = basic set point + dead zone(Adr.0x000E) + offset(Adr. 0x0202) + poti offset* + night lowering (Adr.0x000D)

*if used

3.2 Hardware Installation

The room operating unit can be connected by means of a twisted-pair cable (line resistance 120 Ohm). For detailed information on installation and mounting, please see the product data sheet WRF04-RS485-Modbus & (LCN) FTW04-RS485-Modbus and the data sheet wiring_rs485_network.pdf.

3.3 RS485 Transceiver

The maximum number of bus participants without use of a repeater is preset by the RS485-transceiver. The transceiver used enables 32 devices per bus segment at maximum.

3.4 Protocol

The room operating unit WRF04-RS485-Modbus & (LCN) FTW04-RS485-Modbus is a slave-bus participant only allowed to send to the bus on demand of the master. The protocol corresponds to the defaults of:
- MODBUS Application Protocol Specification V1.1
- MODBUS via Serial Line Specification & Implementation guide V1.0

3.5 Configuration Options

3.5.1 Device addressing

In addition to address setting via dip switch (1-32) an option for address extension (1-247) is implemented. To use extended addressing write a valid address (1-247) to register 16386 (data address 0x4001) and set dip switch to address 0! As long as an dip switch address > 0 is set, the device uses the dip switch address as network address.
To modify register 16386 (data address 0x40001) following sequence must be strictly adhered:
Set valid dip switch address (1-31). Use Modbus command 'Write multiple registers'(FC16) and write value 0x4793 to register 16385 (data address 0x4000) and the selected address to register 16386 (data address 0x4001) in one sequence. Subsequently set dip switch address to 0. Device uses the exntended address setting as network address.
As long as the dip switch address is set to 0 it´s not possible to modify the extended address!!!
6pole DIP switch:

- Bus address of device (1 - 63) via 6 pole DIP switch;

3.5.2 Interface parameters

5pole DIP switch:

- Transmitting mode
  - DIP 1 off: RTU
  - DIP 1 on: ASCII
- Baud rate
  - DIP 2 off + DIP 3 off: 9600
  - DIP 2 on + DIP 3 off: 19200
  - DIP 2 off + DIP 3 on: 57600
- Parity
  - DIP 4 off + DIP 5 off: non
  - DIP 4 on + DIP 5 off: even
  - DIP 4 off + DIP 5 on: odd
- Bus terminating resistor 120 Ohm
  - DIP 6 off
  - DIP 6 on
- The number of data bits is fixed and preset to: RTU 8 data bits and ASCII 7 data bits

As the data sheet contains a detailed description of position and meaning of the jumpers, please refer to the datasheet.

Important notice for operation in the Master/Slave system:

!! The bus address must be adjusted differently for each device

!! Transmission mode, baud rate and parity must be identical

4 WRF04-RS485-Modbus & /LCN) FTW04-RS485-Modbus Protocol

4.1 Control Commands Supported

The following MODBUS – control commands are supported:

Description	Function code	
Read bits	01 (hex)	1 (dez)
	02 (hex)	2 (dez)
Read register	03 (hex)	3 (dez)
	04 (hex)	4 (dez)
Write individual bit	05 (hex)	5 (dez)
Write individual register	06 (hex)	6 (dez)
Write several bits	0F (hex)	15 (dez)
Write several registers	10 (hex)	16 (dez)

Table 1

4.2 Data Administration

All data in a MODBUS-Slave are assigned to addresses. Data access (read or write) is made by the corresponding control command and the indication of the corresponding data address.

Procedure	RTU	ASCII
Read register	20	10
Write register	20	10
Read coils	16	8
Write coils	8	8

4.3 EEprom – non volatile memory

Configuration parameters are not allowed to write permanently. Device has maximum write cycles of nonvolatile memory. (dimension: <10000).

4.4 Register Definition

4.4.1 Holding Registers (read/write)
Registers for device configuration

Protocol Address	Value Range	Description		
0x0000	**0x0003**	**Device coding, not changeable**		
0x0001	**0x0012**	**Firmware version, not changeable**		
0x0002 – 0x0025	**Configuration of the operating unit, EEPROM- data – !! Don't update permanently EEprom !!**			
0x0002	0x0000-0x0010	Device Type	0x0000, Type AO2V (AO1: Heating, AO2: Cooling) (default)	
			0x0001, Type DO2R (DO1: Heating, DO2: Cooling)	
			0x0002, Type DO2T (DO1: Heating, DO2: Cooling)	
			0x0003, Type OVR (DO1: Heating, AO2: Cooling)	
			0x0004, Type OVT (DO1: Heating, AO2: Cooling)	
			0x0005, Type 6WV (AO1: 2…4,7V = cooling, 7,3…10V = heating)	
			0x0006, Type Belimo® 6WV_INV (AO1: 2…4,7V heating , 7,3...10V cooling)	
			0x0007, Type SAUTER 6-way valve DN15	
			0x0008, Type SAUTER 6-way valve DN20	
0x0003	0x0000-0xFFFF	Device location identification (default = 0x0000)		
0x0004	0x0000-0x00FF	Function button	0x00,without special function (default) 0x20, Room unoccupied 0x21, Room occupied 0x22, Room occupancy toggle 0x23, Bypass mode 0x30, Control Auto/Off toggel	
0x0005	0x0000-0xFFFF	Updating interval of display in seconds (default = 0x0A)		
0x0006	0x0000-0x0C80	Min-Response-Delay-Time	signed int, (max 3100 ms) (default = 0x0A = 10 ms)	
0x0007	0x0000-0x00FF	Temperature-Offset for calibration of temperature sensor signed int, e.g. 10_{dec} = +1.0 K, -5_{dez} = -0.5 K (default = 0x00)		
0x0008	0x0000-0xFFFF	Temperature-Offset for calibration of humidity sensor signed int, e.g. 50_{dec} = +5.0%, -30_{dez} = -3.0% (available only on device LCN FTW04 or FTW04)		
0x0009	0x0000-0xFFFF	Upper adjustable range set set point (default: 0x00)	**Temperature** signed int, e.g. 30_{dec} = + 3.0 K	
			Humidity signed int, e.g. 800_{dec} = 80% rH	
0x000A	0x0000-0xFFFF	Lower adjustable range set point (default: 0x00)	**Temperature** signed int, e.g. -30_{dec} = - 3.0 K **(a figure<0 must be input!)**	

Protocol Address	Value Range	Description	
			Humidity signed int,e.g. 200_{dez} = 20% rH
0x000B	0x0000- 0xFFFF	Set temperature – Basic set point after reset	signed int, e.g. 220_{dez} = 22.0 °C (default = 0xDC = 22,0° C)
0x000C	0x0000- 0xFFFF	Set temperature display	0x00 – Basic set point 0x01 – Change over display of heating/cooling set point depending on activated operating mode (default = 0x00)
0x000D	0x0000- 0xFFFF	Night setback (unoccupied) Heating = set point – night lowering Cooling = set point + night lowering	(default = 0x32) e.g. 40_{dec} = 4.0 K
0x000E	0x0000- 0x0064	Dead band between heating and cooling	(default = 0x14) z.B. 20_{dec} = 2.0
0x000F	0x0000- 0x0001	Fan Coil Stage with/without Auto	0x0000 with Auto (default) 0x0001 without Auto
0x0010	0x0000- 0x0064	Proportional range Xp (K) Heating Xp = 0 deactivates controller	(default = 0x14 = 2.0K) e.g. 40_{dec} = 4.0 K
0x0011	0x0000- 0x00FF	Reset time Tn (min) Heating	(default = 0x64) e.g. 100_{dec} = 100 min
0x0012	0x0000- 0x0064	Maximal control variable limit Heating	(default = 0x64) e.g. 100_{dec} = 100 %
0x0013	0x0000- 0x0064	Minimal control variable limit Heating	(default = 0x00) e.g. 10_{dec} = 10 %
0x0014	0x0000- 0x00FF	PWM-Cycle time Heating	(default = 0x0F) e.g. 15_{dec} = 15 min
0x0015	0x0000	reserved	
0x0016	0x0000- 0x0064	Proportional range Xp (K) Cooling Xp = 0 deaktviert den Regler	(default = 0x14 = 2.0K) e.g. 40_{dec} = 4.0 K
0x0017	0x0000- 0x00FF	Reset Time Tn (min) Cooling	(default = 0x64) e.g. 100_{dec} = 100 min
0x0018	0x0000- 0x0064	Maximal control variable limit Cooling	(default = 0x64) e.g. 100_{dec} = 100 %
0x0019	0x0000- 0x0064	Minimal control variable limit Cooling	(default = 0x00) e.g. 10_{dec} = 10%
0x001A	0x0000- 0x00FF	PWM-Cycle time Cooling	(default = 0x0F) e.g.15_{dec} = 15 min
0x001B	0x0000	reserved	
0x001C	0x0000- 0x0064	Frost protection 0x00 deactivates antifreeze	(default = 0x32) e.g. 50_{dez} = 5.0 K
0x001D	Not used		
0x001E	Not used		

Protocol Address	Value Range	Description	
0x001F	0x0000-0x0003 0x0010-0x0013	Selection digital input 1	0x00, Break contact 0x01, Breaker dew point 0x02, Breaker energy hold off 0x03, Breaker occupied 0x04, Breaker controller auto/off 0x05, Breaker controller heating/cooling 0x10, Make contact (default) 0x11, Maker dew point 0x12, Maker energy hold off 0x13, Maker occupied 0x14, Maker controller auto/off 0x15, Maker controller heating/cooling
0x0020	0x0000-0x0003 0x0010-0x0013	Selection digital input 2	
0x0021	0x0000-0x0002	Counter mode digit.input1	0x00, edge 0x01, pulse 0x02, duration
0x0022	0x0000-0x0002	Counter mode digit.input 2	
0x0023	0x0000-0x0078	Bypass time occupancy (min)	0x00 – off (default) e.g. 0x0078 = 120_{dec} = 120 min
0x0024	0x0000-0x0001	Trigger LED	0x00, external trigger 0x01, occupied (ON)/unoccupied(OFF) (default) 0x02, controller active(ON)/inactive(OFF) 0x03, controller cooling active(ON)/inactive(OFF) 0x04, controller heating active(ON)/inactive(OFF)
0x0025	0x0000-0x0003	Controller mode after reset and Off	0 – Controller off 1 – Controller heating 2 – Controller cooling 3 – Controller automatic
0x0026	0xFFFF 0x0000-0x0064	Type: AO2V, OVR, OVT, 6WV Analogue value 0-10V after communi-cation failure **Output1 Heating**	Signed int, e.g. 1000_{dec} = 100% 0xFFFF = -1 = keep last value
		Type: DO2R, DO2T Digital value after communication failure **Output1 Heating***	0 - Open >=1 - Closed 0xFFFF = -1 = keep last value
0x0027	0xFFFF 0x0000-0x0064	Type: AO2V, OVR, OVT, 6WV Analogue value 0-10V after communi-cation failure **Output2 Cooling**	Signed int, e.g. 1000_{dec} = 100% 0xFFFF = -1 = keep last value
		Type: DO2R, DO2T Digital value after communication failure **Output2 Cooling***	0 - Open >=1 - Closed 0xFFFF = -1 = keep last value

4.4.2 Input Registers (read only)
Registers for output of values, states, …

Protocol Address	Value Range	Description	
0x0100 – 0x0111	**Measuring value (data output)**		
0x0100	0x0000-0x000F	bit0 button 1=pressed, 0=not pressed	
0x0101	0x0000-0x000F	It is buffered if a button was actuated since the last read out of the register. After the read out, all bits are reset to the actual value. bit0 button 1= pressed 0=not pressed	
0x0102	0x0000-0xFFFF	Temperature	signed int, e.g. 184_{dec} = 18.4 °C
0x0103	0x0000-0xFFFF	Set temperature offset*	signed int, Temperature: e.g. -25_{dez} = -2.5K Humidity : e.g. 510_{dez} = 51%
0x0104	0x0000-0xFFFF	Set temperature effective	signed int, e.g. 220_{dec} = 22.0 °C
0x0105	0x0000-0x03E8	Humidity	unsigned int, z.B. 500_{dez} = 50.0% **(available only on device LCN FTW04 or FTW04)**
0x0106	0x0000-0x0003 0xFF00-0xFF03	Fan coil stage	0x0000 – off 0x0001 – stage1 0x0002 – stage2 0x0003 – stage3 0xFF00 – auto
0x0107	0x0000-0x0001	Occupancy mode	0 – unoccupied 1 – occupied
0x0108	0x0000-0x03FF	Regulating variable heating	unsigned int, e.g. 1023_{dec}=100.0% range 0-1023 corresponds to. 0-100%
0x0109	0x0000-0x03FF	Regulating variable cooling	unsigned int, e.g. 1023_{dec}=100.0% range 0-1023 corresponds to 0-100%
0x010A	0x0000-0x0001	Local controller lock	0 – not locked 1 – locked
0x010B	0x0000-0x03E8	Type: AO2V Analogue output value 0-10V **Output1 Heating***	Unsigned int, e.g. 500_{dec} = 5V
		Type: DO2R, DO2T, OVR, OVT Digital output state **Output1 Heating***	0 – open 1 - closed
		Type: 6WV Control voltage for 6-way valve on AO1	0…1000dec = 0…10V
0x010C	0x0000-0x03E8	Type:AO2V, OVR, OVT Analogue output value 0-10V **Output2 cooling**	Unsigned int, z.B. 500_{dez} = 5V

		Type: DO2R, DO2T Digital output state **Output2 cooling**	0 – open 1 - closed
		Type: 6WV Control voltage for 6-way valve on AO2	0…1000dec = 0…10V
0x010D	0x0000-0x0001	Digital input1	0 - open 1 - closed
0x010E	0x0000-0x0001	Digital input2	0 - open 1 - closed
0x010F	0x0000-0xFFFF	Counter value digit. Input1**	0-65535
0x0110	0x0000-0xFFFF	Counter value digit. Input2**	0-65535
0x0111	0x0000-0x0003	Controller mode	0 = stop of controller 1 = heating 2 = cooling 3 – automatic heating control 4 – automatic cooling control

* Value output of local set point adjuster (poti). Depending on assignment of potentiometer!

** With any reading out of the counter the value is zeroed! The counter mode is depending on the adjustment of the corresponding configuration property.

4.4.3 Holding Registers (read/write)
Registers to overwrite values, states, …

Protocol Address	Value Range	Description	
0x0200 – 0x0205	**Control (ext. data default)**		
0x0200	0x0000-0xFFFF	Ext. temperature default	signed int, z.B. 170_{dez} = 17.0°C
0x0201	0x0000-0x03E8	Ext. humidity default	unsigned int, z.B. 1000_{dez} = 100.0% **(available only on device LCN FTW04 or FTW04)**
0x0202	0x0000-0xFFFF	Set point offset	signed int, z.B. -25_{dez} = -2.5K einblenden mit Coilregister 0x0005
0x0203	0x0000-0xFFFF	Base set point	signed int, z.B. 220_{dez} = 22 °C
0x0204	0x0000-0x0001	Occupancy mode	0 – unoccupied (default) 1 – occupied 2 – bypass mode
0x0205	0x0000-0x0003	Controller mode*	0 = controller off 1 = heating (cooling deactivated) 2 = cooling (heating deactivated) 3 = automatic (default)
0x0206	0x0000-0x03E8	Type: AO2V Analogue manual output value 0-10V **Output1 Heating***	Unsigned int, e.g. 500_{dec} = 5V Value higher 1000 = automatic mode
		Type: DO2R, DO2T, OVR, OVT Digital manual output state **Output1 Heating***	0 – open 1 - closed Value higher 1 = automatic mode
		Type: 6WV Control voltage for 6-way valve on AO1	0…1023dec = 0…10V Value higher 1000 = automatic mode
0x0207	0x0000-0x03E8	Type:AO2V, OVR, OVT Analogue manual output value 0-10V **Output2 cooling**	Unsigned int, z.B. 500_{dez} = 5V Value higher 1000 = automatic mode
		Type: DO2R, DO2T Digital manual output state **Output2 cooling**	0 – open 1 - closed Value higher 1 = automatic mode
		Type: 6WV Control voltage for 6-way valve on AO1	0…1023dec = 0…10V Value higher 1000 = automatic mode

*Mode change-over upon use of a 2-wire pipe system, i.e. warm and cold water are sharing the inflow and waste pipe (Change-Over operation, please also see configuration bit Change-Over-operation (Coil 0x000C)). Active frost protection automatically activates the heating controller.

4.4.4 Extended address range

Register	Data Address	Value Range	Description
16385 – 16386 R/W	**0x4000 – 0x4001**		
16385 R/W	0x4000	0x4793	Access protection
16386 R/W	0x4001	1-247$_{dez}$	Extended address

To modify extended address strictly adhere to sequence as described in chapter 2.12.1!

Protocol-Address	Description
0xFF00 – 0xFFFF	**Range defined by the manufacturer, not allowed to be changed!**

4.5 Bit Allocation / Coil Definition

4.5.1 Output Coils (read/write)
Bits for device configuration

Protocol Address	Description	
Configuration of Operating unit Bit-Register, EEPROM- Data Configuration of Display – !! Don't update permanently EEprom !!		
0x0000	Room temperature	1=display (default) 0 = do not display
0x0001	Humidity **(available only on device LCN FTW04 or FTW04)**	1 = display 0 = do not display (default)
0x0002	Set point humidity	1 = display 0 = do not display (default)
0x0003	Set point temperature	1 = display 0 = do not display (default)
0x0004	Set point temperature	1 = absolute 0 = offset (default)
0x0005	Change of set point temperature	1 = absolute 0 = offset (default)
0x0006	°C/°F	1 = °C (default) 0 = °F
0x0007	Humidity display **(available only on device LCN FTW04 or FTW04)**	1 = with RH (default) 0 = without RH
0x0008	Use Minimal Control Variable with control variable > 0: = 1 Use Minimal Control Variable with control variable = 0: = 0 (default)	
0x0009	Room occupancy after reset	1 = occupied (default) 0 = unoccupied
0x000A	Not used	
0x000B	Not used	
0x000C	Change over mode	0 – 4-wire-system (default) 1 – 2-wire-system*
0x000D	Poti assignment	0 – Temperature (default) 1 – Humidity

* If the Change-Over operation is activated, the corresponding mode of the controller (heating,cooling) must be defined via the Holding Register „Control mode" with the data address 0x205 or by one of the digital inputs. **The Change-Over operation runs via output1.**

4.5.2 Output bits (read/write)
Bits to overwrite values, states, …

Protocol Address	Description	
External control Bit-Register		
0x0100	Status signal dew point	0 – Dew point inactive (default) 1 – Dew point active
0x0101	Status signal energy hold off	0 – Energy hold off inactive (def.) 1 – Energy hold off active
0x0102	Release of local presence button[1]	0 – Locked 1 – Released (default)
0x0103	Release of controller[2]	0 – Locked 1 – Released (default)
0x0104	Trigger LED[3]	0 – OFF (default) 1 – ON

[1] *Release* – Change of presence model vial local presence button possible
Locked– Local presence buttons are locked
[2] *Controller locked*– Both controllers are inactive, active antifreeze automatically activates the heating controller
Release Controller – Both controllers are released, the controllers are working in the controller mode, which is set in the corresponding configuration property „Controller Mode“.
[3] The *LED* can only be controlled, if the configuration register for the LED control is parameterized, accordingly!

5 Data Transmission

5.1 Master/Slave Protocol

One master and one or more slaves are connected to the serial bus. The communication between master and slave is exclusively controlled by the master. The slaves are only allowed to send if they have been addressed by the master before. Slaves are only sending back to the master, never to another slave.

5.2 Data Frame

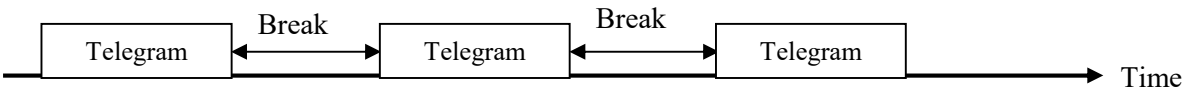
The data are sent to the bus in accordance to severely defined defaults:

Address	Control command	Data	Checksum

In general, a MODBUS telegram starts with the address of the slave, followed by a control command (e.g. read register) and the data. By means of the checksum at the telegram end, the bus participants can recognize transmission errors.

5.3 Transmission Mode RTU

In the transmission mode RTU telegrams are separated by means of transmission breaks:



The period of the transmission breaks for separating telegrams is depending on the adjusted baud rate and amounts to 3,5 * word transmission time (11 bit). With 9600 baud at least 4 ms must pass by and with 57600 at least 1 ms must pass by between two telegrams.

5.3.1 Telegram Layout

Address 1 Byte	Control command 1 Byte	Data 0 - 100 byte	Checksum	
			CRC Low	CRC High

5.3.2 Calculation of CRC-Checksum

The CRC checksum (Cyclical Redundancy Check) is calculated by the sender out of all bytes transmitted and is attached to the message.

The receiver re-calculates the CRC checksum and compares it with the checksum received. If the values do not correspond, a transmission error is assumed and the data received are rejected.

The least significant byte of the 16 bit checksum is set to the penultimate location and the most significant byte is set at last location.

Calculation of checksum (Programming example in C):

```
crc = 0xFFFF;                                   // CRC-Check, Initialisation
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

// Function definition CRC calculation
unsigned int    crc_calc(unsigned int    crc_temp, unsigned int data)
{
        unsigned int    Index_CC=0;             // Loop counter
        unsigned int    LSB=0;                  // Help variable

        // Exclusive-Oder des 8Bit-Char with the lower 8Bit of CRC
        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 für CRC16
        }

        return(crc_temp);
}
```

5.4 Transmission Mode ASCII

The ASCII transmission mode does not make that high demands on the computer speed of the bus participants. The telegrams are not separated by break times, but by ASCII control characters.

5.4.1 Telegram Layout

The ASCII control character „: “always identifies the beginning of a telegram. The ASCII control characters „CR“and „LF“identify the end of a telegram. The telegram data are output hexa-decimal in the ASCII format:

e.g.: 197dez (1Byte) = C5hex (1 Byte) = C (1 Byte) 5 (1 Byte) ASCII

As one data byte is displayed by 2 ASCII characters, the number of data bytes to be transmitted is doubled compared with the RTU mode.

Start 1 char	Address 2 char	Control command 2 char	Data 0 - 2 x 100 char	Checksum LRC 2 char	End 2 char
:					**CR LF**

5.4.2 Calculation of LRC-Checksum

The LRC checksum (Longitudinal Redundancy Check) is calculated by the sender out of all bytes transmitted (without „:“, „CR“, „LF“) and pasted in the message of „CR„ and „LF“. The receiver re-calculates the LRC checksum and compares it with the checksum received. If the values do not correspond, a transmission error is assumed and the data received are rejected.

The most significant ASCII character of the 8 bit checksum is sent in the telegram before the least significant ASCII character.

Calculation of checksum (programming example in C):

```
lrc = 0;
for(i = 1; i < Telegram length -4; i++)
        lrc = lrc + Telegram data [i];

lrc = 0xFF - lrc;
lrc = lrc + 1;
```

6 Examples: Telegrams

6.1 Register

The operating unit has different registers for the configuration, for the display of values and for the input values.

6.1.1 Configuration of parameter

The operating unit can be parameterized by the configuration registers 3-42 and the control commands „Write Register“(10hex or 06hex).

Example: Digital input 1 as breaker dew point and digital input 2 as maker energy hold off.

Master - Telegram in Transmission Mode RTU:

Device	command	Start address		Number of registers		Number of Bytes	Data Register 1F		Data Register 20		Check Sum	
		H Byte	L Byte	H Byte	L Byte		H Byte	L Byte	H Byte	L Byte	L CRC	H CRC
02	10	00	1F	00	02	04	00	01	00	12	CRC	

Slave – Response Telegram in Transmission Mode RTU:

Device	command	Start Address		Number of Register		Check Sum	
		H Byte	L Byte	H Byte	L Byte	L CRC	H CRC
02	10	00	06	00	02	CRC	

6.1.2 Read-Out of Output Register

Button and digital input status and values are stored in the output registers. After a reset the basic set points are taken over from the configuration registers for the corresponding set points.

Master - Telegram in Mode RTU		**Slave – Response Telegram in Mode RTU**		
Description	Value (Hex)	Description		Value (Hex)
Slave Address	02	Slave Adresse		02
Command	03	Command		03
Start address High	01	Number of Bytes		14
Start address Low	00	Register value High (0100)		00
Number of Registers High	00	Register value Low (0100)	Button state	01
Number of Registers Low	04	Register value High (0101)		00
Checksum Low	CRC	Register value Low (0101)	Button memory	01
Checksum High		Register value High (0102)	Temperature	00
		Register value Low (0102)	Temperature	DC
		Register valueHigh (0103)	Set point offset	FF
		Register Wert Low (0103)	Set point offset	E7
		Checksum Low		CRC
		Checksum High		

6.1.3 Setting of Input Registers

By means of the input registers different values can be overwritten in the operating unit.

Example: Activate occupancy bypass mode

Master - Telegram in Transmission mode RTU:

Device	Command	Start address		Data Register 513		Checksum	
		H Byte	L Byte	H Byte	L Byte	L CRC	H CRC
02	06	02	04	00	02	CRC	

Slave – Response telegram in Transmission mode RTU:

Device	Command	Start address		Number of Registers		Checksum	
		H Byte	L Byte	H Byte	L Byte	L CRC	H CRC
02	10	02	04	00	02	CRC	

6.2 Coil / Bit Allocation

The operating unit has different configuration bits for adjusting the display value of the display.
By means of the input bits different LEDs, controller etc. can be controlled.

Writing Configuration Bits
By means of the control command „Write Bit(s)“ (0Fhex or 05hex) a configuration bit (or more) can be written with the value „1“ or „0“.

Example: Dispay Set point temperature

Master - telegram in Transmission mode RTU:

Slave Address	commandl	Start address		Number of bits		Number of bytes	Data	Checksum	
		H Byte	L Byte	H Byte	L Byte		H Byte	L CRC	H CRC
02	0F	00	04	00	01	01	01	CRC	

Slave – response telegram Transmission mode RTU:

Slave Address	command	Start address		Number of bits		Checksum	
		H Byte	L Byte	H Byte	L Byte	L CRC	H CRC
02	0F	00	04	00	01	CRC	

6.2.1 Read Bits

By means of the control command „Read bits“(01_{hex} or 02_{hex}) one or more bits can be read out.

Example: Inquiry of operating mode of outputs (Data Address = $0000A_{hex}$ $0000B_{hex}$) -> Here: Both outputs are in manual operation

Master - Telegram in Mode RTU		**Slave – Response Telegram in Mode RTU**	
Description	Value (Hex)	Description	Value (Hex)
Device	02	Device	02
Command	01	Command	01
Start address High	00	Number of bytes	01
Start address Low	0A	Bit value 0,0,0,0,0,0,bit1,bit0	02
Number of bits High	00	Checksum Low	CRC
Number of bits Low	02	Checksum High	
Checksum Low	CRC		
Checksum High			

7 Configuration Software

By means of a RS485-interface (e.g. RS232-RS485-level converter e.g. ADAM-4520) it is possible to access to the Modbus by the configuration software. The configuration software is not obligatory necessary for the installation of the WRF04-RS485 Modbus. It is possible to use any programme producing Modbus telegrams which is suitable to set registers.

8 Software Installation

For the installation of the configuration software, the setup files „WRF04_FTW04_Modbus_ Config_Setup.exe “must be started. Please note that you must have administrator rights for the installation. During the installation, please follow the screen instructions.

After a successful operation, the configuration software can be started via the
“Starting Menu/Programs/Thermokon“

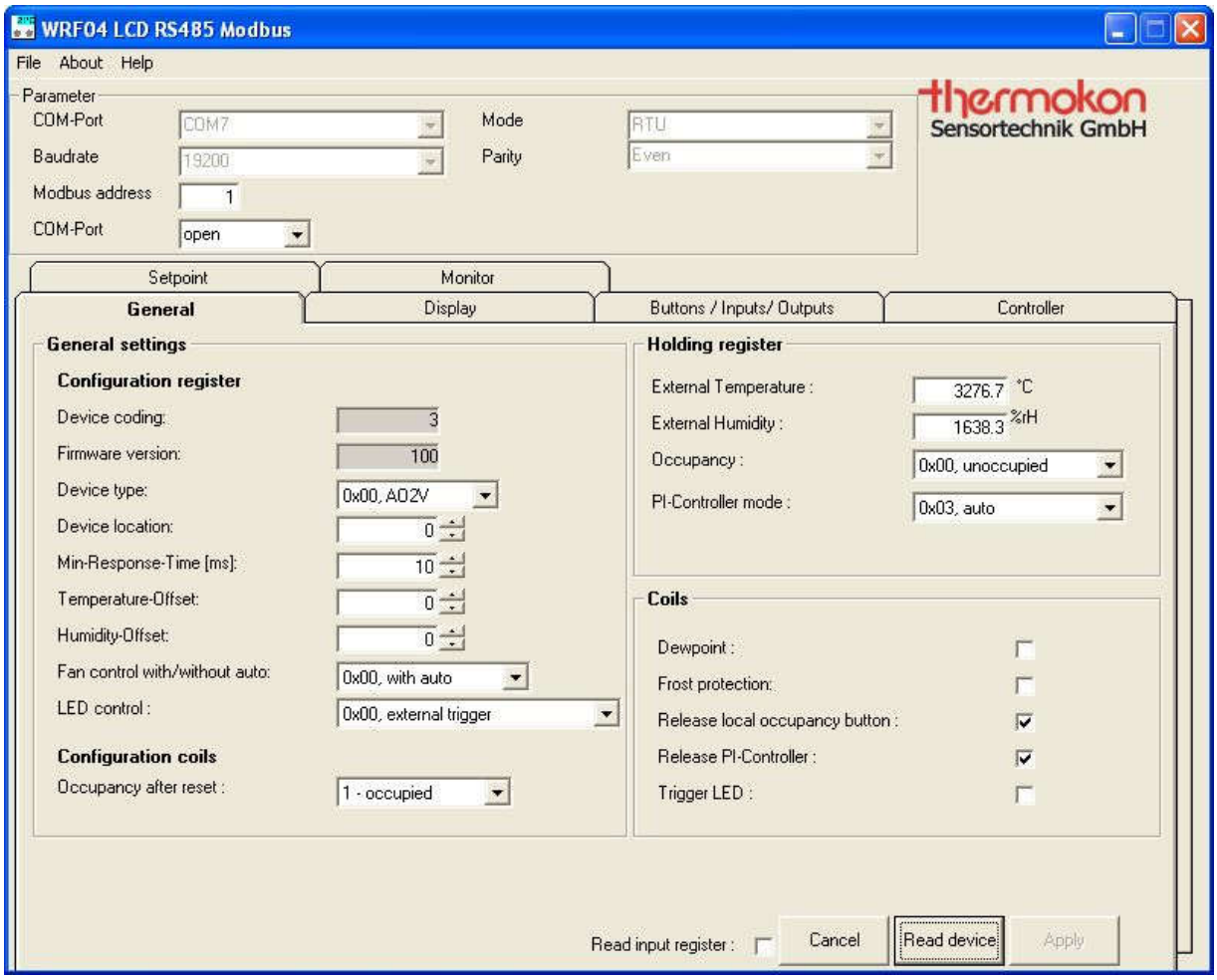
Operating systems 32-Bit supported:
Windows9x; WindowsNT; WindowsMe; Windows2000; WindowsXP; WindowsServer; Windows 7

9 Configuration of WRF04-RS485-Modbus & (LCN) FTW04-RS485-Modbus

9.1 Software Configuration

By means of the configuration software the configuration registers can be clearly adjusted. Output registers of the WRF04 / FTW04 can be read out and input registers can be set. The load of the individual registers is described in chapter 2.4!

Via the menu points "File" and "Saving of Parameter" respectively "Loading of Parameter", the configuration registers can be stored in a text file and can be reloaded into the WRF04-RS485-Modbus / (LCN) FTW04-RS485-Modbus.



Picture 9-1: Configuration software

9.2 Parameter-Frame

The Modbus can be accessed via the configuration software by means of a COM-Port. In the "Parameter"-Frame hardware settings can be made. They must be in conformity with the Modbus receiver, in order to produce a connection.

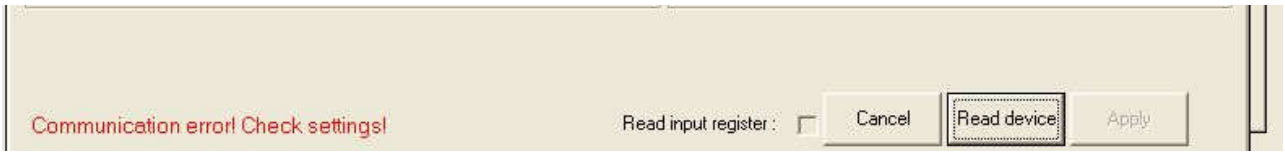
The following options can be selected:

- COM-Port
- Baud rate 9600 , 19200, 57600
- Parity none, even, odd
- Modus for setting of transmission ASCII or RTU
- Modbus address (1-31)

In the field "Modbus address" the address of the WRF06-RS485 Modbus that shall be configured is entered (value between 1 and 31).

Via the selection menu behind "COM-Port" the port can be opened "open" and closed "close".
If the COM-Port is used alreasdy, an error message is shown.

After having opened the COM-Port, the current register values of the device can be read out via the button “read out device“. If no connection to the device can be made, the same is shown by an error message.



Picture 9-2: Communication Problems

9.3 Register

The configuration registers can be set in the different tabs. Furthermore, the output registers can be read and the input registers can be set.

Changes are sent to the WRF06-RS485 Modbus after having pressed the button "take over". By actuating the button "Cancel" the registers of the WRF06-RS485-Modbus are read out again.

By activating the hook "read output register" all output registers are read out cyclically.

Picture 9-3: Data