Serial interface for HB-Therm Temperature Control Units (Protocol 1, 4, 5)

Contents

1 Concept of Interface

The production computer monitors and co-ordinates the production machines and manages data, moulds and materials. The setup parameters for the complete production process may also be transferred to the production machine via any data carrier.

The machine communicates with the temperature control unit via a serial interface. Set values are transferred to the unit while the unit itself has an autonomous control system for its process. Via the same interface the machine can monitor the unit.

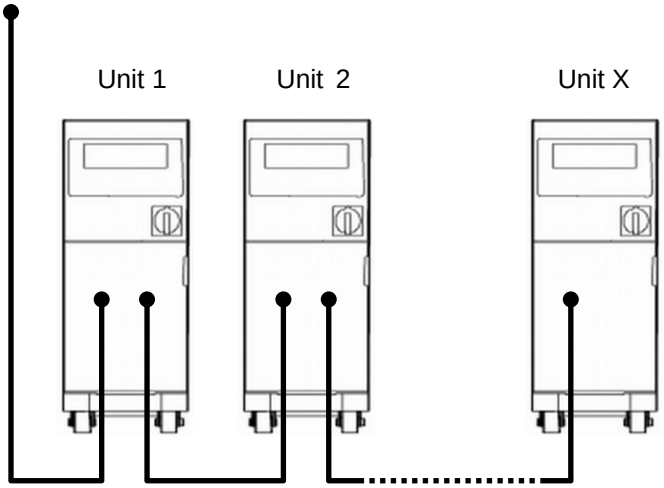
1.1 Basic Layout

As interface between machine control and temperature control unit, standard interfaces such as:

- RS-232 (V.24)
- RS-422 or RS-485
- CAN-Bus
- PROFIBUS-DP
- 20 mA Stromschlaufe

The connection from temperature control unit to temperature control unit is:

- RS-422, CAN or Profibus with USR version
- 20 mA current loop with controller version



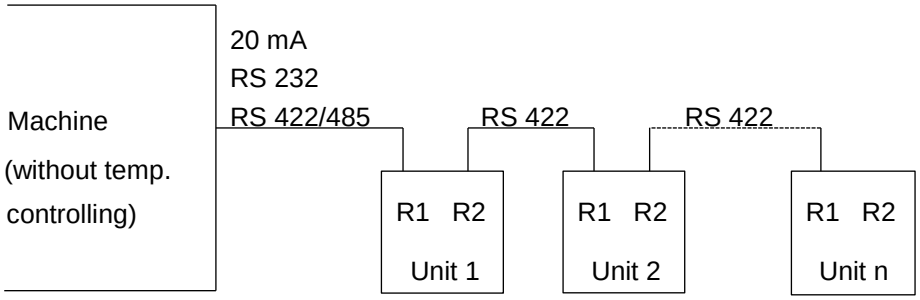
2 Description of Hardware

The following hardware interface may be used with the temperature control unit:

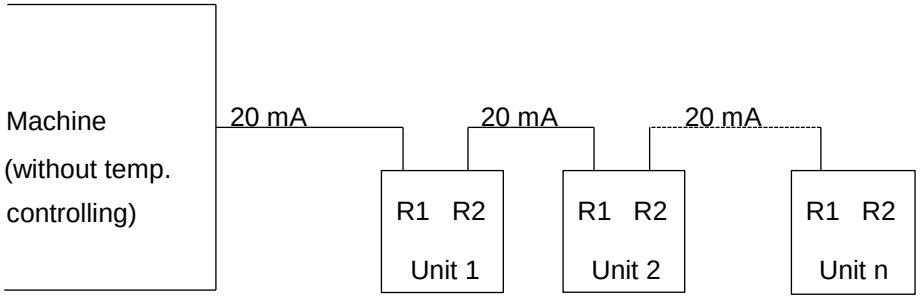
- 20 mA Current loop
- RS 232 (only available for units with USR)
- RS 422/485 (only available for units with USR)

The link between the temperature control units with USR is done via RS-422, controller type units via 20 mA (Current loop). Exceptions are Profibus and CAN-Bus.

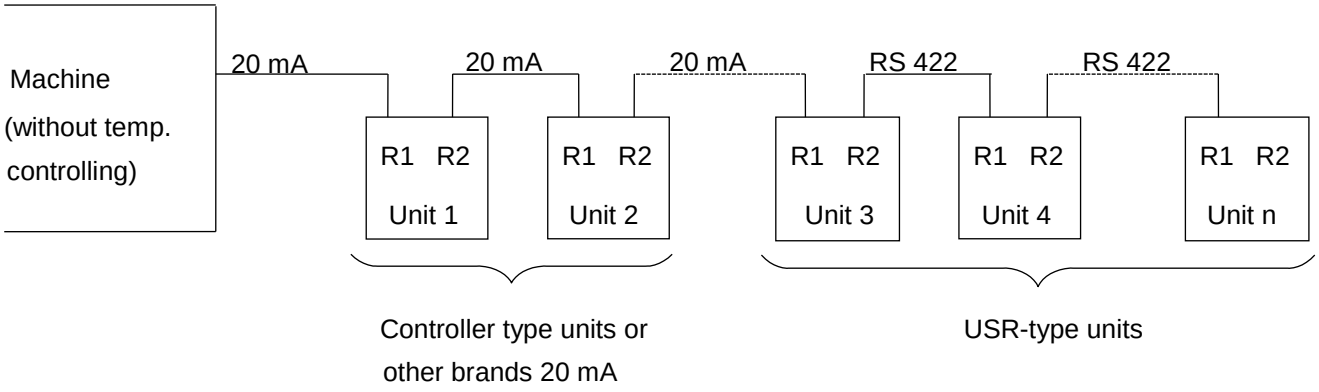
2.1 Operation with USR type units



2.2 Operation with controller type units



2.3 Operation with USR and controller type units



Type of Connector

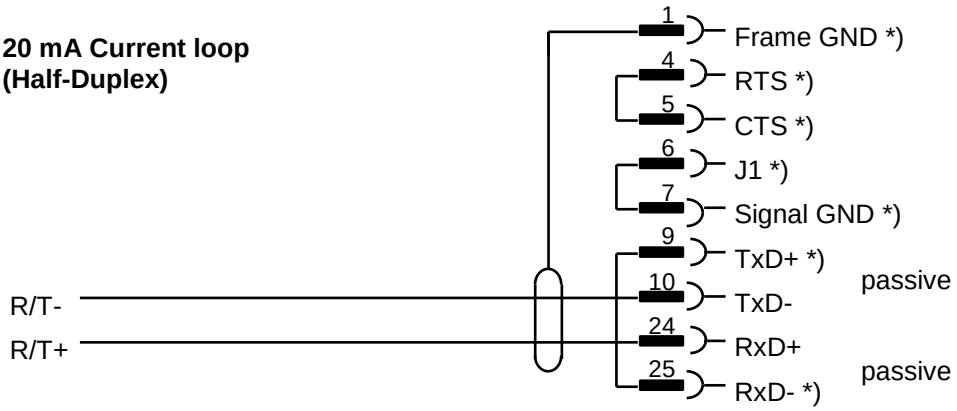
Subminiature D, 25-pole according to DIN 66021

Notes for the operation with 20 mA Current loop:

- *With Half-Duplex operation, both transmitter and receiver are connected in series and the master hears its own message (echo)*
- *The voltage drop per unit may be up to 2 V*
- *The machine is active, the temperature control unit react passive*

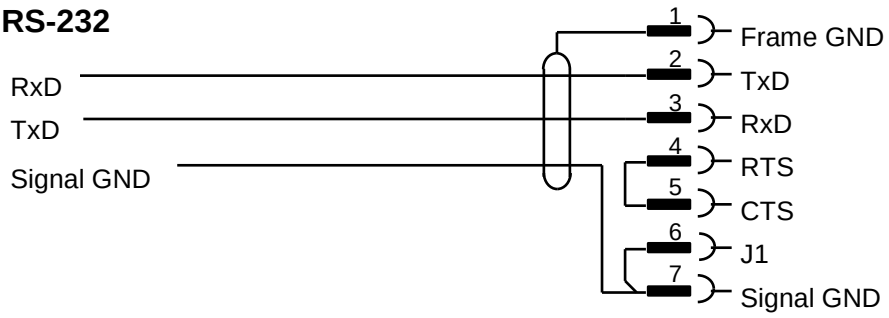
2.4 Pin Assignment for the Various Types of Interfaces

20 mA Current loop (Half-Duplex)



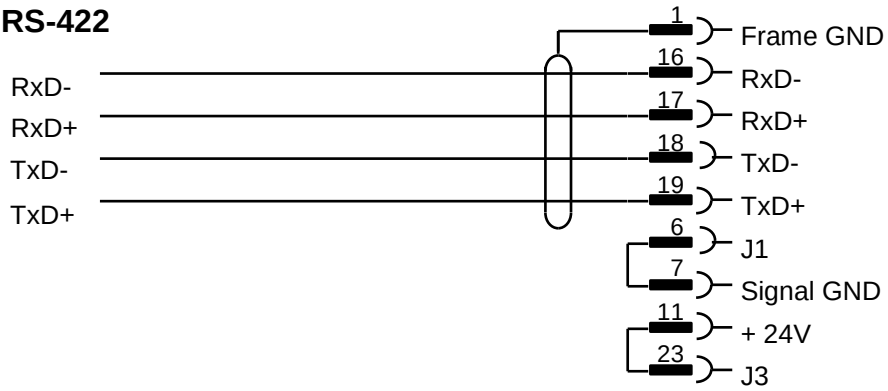
*) not for controller type units XS/XP 74 (HB-Therm/R1/20mA)

RS-232



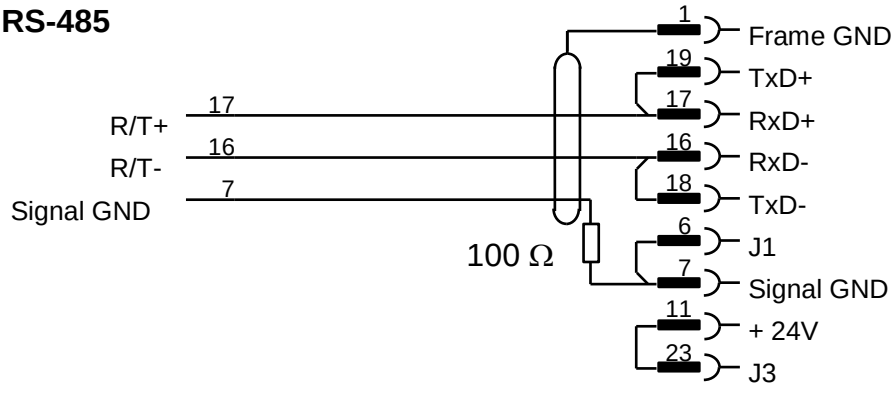
XS/XP 74 (HB-Therm/R1/RS 232)

RS-422



XS/XP 74 (HB-Therm/R1/RS422)

RS-485



XS/XP 74 (HB-Therm/R1/RS485)

3 Description of Software

This description specifies the HB-Therm Protocols 1, 4 and 5, which are used in connection with the following injection moulding machine manufacturers (2006):

Protocol	Injection moulding machine manufacturer
1	Arburg, Billion, Bühler (DATACESS, DATASPEED), Dr. Boy, Ferromatik Milacron, Haitian, KraussMaffei, MODBUS (RTU-Mode), Negri Bossi, SPI (Fanuc, etc.), Stork, Sumitomo Demag, Wittmann Battenfeld, Zhafir
4	Engel
5	Stork

3.1 Communication between Production Machine and Temperature Control Unit

The data transmission between production machine (hereafter called **“Machine”**) and temperature control unit (hereafter called **”Unit”**) is activated basically by the Machine (master-slave-system); therefore the Unit sends data only on request of the Machine.

Protocol number and Unit address are set on the Unit. This allows the Unit to operate on different types of Machine (different protocol types). The Unit address makes it possible to operate more than one Unit via a single interface port on the Machine.

3.1.1 Operating Principle

- The Machine sends set temperature and operating mode to the Unit.
- The Unit then transmits actual temperature, power output and status (operating mode and alarms) to the Machine.
- If the Unit detects a transmission error in the message from the Machine, it will answer with the message 'not acknowledged'. The Machine may repeat the message again.

3.2 Safety Concept

Since there is a chance of errors in the data transmission, several safety stages are used.

- Each byte uses a parity bit.
- The data transfer is based on a master slave system. The master (Machine) requests the slave (Unit) to send, while the slave gets active only upon request. Only the slave confirms the request message, either by answering with the corresponding answer (that means the message is acknowledged) or with the message 'not acknowledged'. In the case of message 'not acknowledged' the master may repeat the request message.
- Each message includes 3 bytes (ASCII-code) which contains the block length as a binary number of bytes of the complete message (including the checksum bytes). The receiver compares the value with the number of received bytes.
- Each message is terminated with 2 bytes of checksum. The bytes for the checksum (ASCII-code) is the 8-bit binary sum of all bytes of the message, excluding the checksum bytes itself.

3.3 Transmission Protocol

The structure of the transmission protocol is basically the same for Machine and Unit. Only ASCII-codes are transmitted. For the Unit address the most significant bit (bit 7) is set to 1 (=80_H). For the following bytes of the message it is set to 0. This is only for messages sent by the master. For the Units it is easy to identify the messages specified for them.

Byte Format

Transmission	asynchronous
Bit pattern	1 start bit 8 data bit (Bit 0 = LSB, Bit 7 = MSB) 1 parity bit 1 stop bit
Parity	even (protocol 4 (Engel): none)
Baud rate	4800 Baud (Protocol 5 (Müller Weingarten, Stork): 9600 Baud
Timing	T1 = 50 ms Maximum possible time between the start bits of the same message. T2 = 100 ms Maximum possible time between the end of a master message and the start of a slave message. The master accepts slave messages only after a message from the master was sent.

Pseudo - ASCII

For block length and checksum a hexadecimal code is used, while set and actual values use BCD. For the transmission the hexadecimal values are converted into ASCII-code. The values higher 9 (A–F) use the codes 3A - $3F_H$ instead of 41 - 46_H.

Physical Units

All temperatures are transmitted in the Celsius scale, the flow rates in L/min. This remains unchanged even if different units are selected for the display on the Unit.

3.4 Structure of a Message

For the communication a basic type (standard) and two special types with the additional transmission of the actual flow rate exist. In one case it is done by using another record name, in the other case a specific value instead of a reserve byte is used. The four bytes for the actual flow rate are added in different positions of the protocol, depending on the type.

Protocol Type	**Master**				**Slave**			
	Record	7th user byte (reserve)	Record	Length	Flow rate int. after power output	Flow rate int. after status	Flow rate ext. 1..8 after Flow rate int. (type 3) resp. status (type 4)	Return line ext. 1..8 after flow rate ext
Standard	41	20	41	19	-	-		
Type 1 (e.g. Arburg, Engel)	41	21	41 *)	23	4 Bytes	-		
Type 2 (e.g. Krauss Maffei, Battenfeld)	71	20	71	23	-	4 Bytes		
Type 3 (e.g. Krauss Maffei)	61	20	61	55	-	4 Bytes	32 Bytes **)	32 Bytes **)
Type 4 (e.g. Arburg)	41	22	41 *)	55	4 Bytes		32 Bytes **)	32 Bytes **)

*) Units without flow rate measuring device respond with the standard answer.

**) If no external flow meter is connected to the TCU the value 0 is transmitted for Flow rate ext 1..8 and Return line ext. 1..8.

- *HB-Therm Temperature Control Units Series 4 meet the requirements for the flow rate type 1 with software version 0446 and for flow rate type 2 with software version 0533.*
- *HB-Therm Temperature Control Units Series 5 meet the requirements for the flow rate type 1 and 2 with software version SW51-1_0812B and for the external flow rate and return line type 3 und 4 with software version SW51-1_1119A.*
- *The types of protocol with the additional internal flow rate also the external flow rate and the return line are usually not included in the standard software if the processing machine (further inquiry with the corresponding manufacturer might be necessary).*

The structure of the massage is as follows:

Byte	**Description**	**Range**
1.	Unit address (for Unit 1–15 resp. 1–36) - message from Machine to Unit - message from Unit to Machine	 B1 ... BF_H bzw. B1 ... $D4_H$ 31 ... $3F_H$ bzw. 31 ... 54_H
2.–4.	Block length, binary number of bytes of a complete message (including checksum byte)	$30,30,37_H$ ... 3F, 3F, $3F_H$
5.	Datensatzkennung (Meldungsart) - set and actual values (without resp. with flow rate type 2 resp. with internal and external flow rate and return line external) - 'not acknowledged'	 41_H bzw. 71_H bzw. 61_H $7F_H$
6.–n.	Content of message (set value, actual value etc.). The message 'not acknowledged' has no content.	
n+1., n+2.	Checksum (last 2 bytes)	30, 30_H ... 3F, $3F_H$

3.5 Content of a Message

3.5.1 The Master Message (Machine → Unit)

This message contains the set temperature and a command for the operating mode of the temperature control unit (record name 41_H resp. $71_{H,}$ block length 14 bytes)

4 Bytes	Set temperature in (-99,9 ... -00,1 °C)		$2D,39,39,39_H$ ... $2D,30,30,31_H$
	(000,0 ... 999,9 °C)		$30,30,30,30_H$ ... $39,39,39,39_H$
1 Byte	Reserve		60_H
1 Byte	Operating mode		
	Controlling (normal mode)	**'r'**	72_H
	Cooling to safety switch-off temperature and switching off *Feedback:* **'k'** unit cooled to safety switch-off temperature **'p'** if switched off	**'p'**	70_H
	Cooling and switching off *Feedback:* **'k'** unit cooled to switch-off temperature **'p'** if switched off	**'k'**	$6B_H$
	Mould evacuation and switching off *Feedback:* **'s'** until mould evacuation is finished **'p'** if switched off	**'s'**	73_H
	Cooling, mould evacuation and switching off *Feedback:* **'a'** until cooled to switch-off temperature **'s'** until mould evacuation is finished **'p'** if switched off	**'a'**	61_H
1 Byte	Reserve resp. flow rate type 1 resp. 4		20_H resp. 21_H resp. 22_H 20_H bzw. 21_H bzw.22_H

*At controller type units, the **'p'** command (unit OFF) is executed in the case of the commands **'k'**, **'s'***

3.5.2 The Slave Answer (Unit → Machine)

The Unit answers the master message with actual values and status-information (record name 41_H resp. 71_H, block length 19 resp. 23 bytes)

4 Bytes	Actual Temperature in °C		
	(-99,9 ... -00,1 °C)		$2D,39,39,39_H$ ... $2D,30,30,31_H$
	(000,0 ... 999,9 °C)		$30,30,30,30_H$ ... $39,39,39,39_H$
4 Bytes	Power output in %		
	(-100 ... -001 %)		$2D,31,30,30_H$ ... $2D,30,30,31_H$
	(0000 ... 0100 %)		$30,30,30,30_H$ ... $30,31,30,30_H$
4 Bytes (optional)	Actual flow rate in L/min (Type 1 resp. 4) (000,0 ... 999,9 L/min)		$30,30,30,30_H$ ... $39,39,39,39_H$
1 Bytes	Status feedback (bit code)		
	Bit 0	Remote mode	(0 = Machine, 1 = Unit)
	Bit 1	Heat sensor mode [1)]	(0 = external, 1 = internal)
	Bit 2	Inadmissible set point received	(= 1)
	Bit 3	Reserve	(= 0)
	Bit 4	Common alarm (detail in the next byte)	(= 1)
	Bit 5, 6, 7	Code fix	(= 1, 1, 0)
1 Bytes	Status feedback for alarm 1 (common alarm is set additionally)		
	Bit 0	Heat sensor failure	(= 1)
	Bit 1	Heater failure [2)]	(= 1)
	Bit 2	Cooler failure [2)]	(= 1)
	Bit 3	Level low [2)]	(= 1)
	Bit 4	Flow rate low [2)]	(= 1)
	Bit 5	Heater overtemperature	(= 1)
	Bit 6, 7	Code fix	(= 1,0)
1 Bytes	Status feedback for alarm 2 (common alarm is set additionally)		
	Bit 0	Pump failure [2)]	(= 1)
	Bit 1	Phase failure [2)]	(= 1)
	Bit 2	System failure	(= 1)
	Bit 3, 4, 5	Reserve	(= 0,0,0)
	Bit 6, 7	Code fix	(= 1,0)
1 Bytes	Status feedback operating mode		
	Cooling, mould evacuation and switching off active	**'a'**	61_H
	Cooling and switching off active	**'k'**	$6B_H$
	Unit OFF	**'p'**	70_H
	Controlling (normal mode)	**'r'**	72_H
	Mould evacuation	**'s'**	73_H

4 Bytes	Actual flow rate in L/min (Type 2 resp. 3)	
(optional)	(000,0 ... 999,9 L/min)	$30,30,30,30_H$ ... $39,39,39,39_H$
4 Bytes	Actual flow rate ext.1 in L/min (Type 3 resp. 4)	
(optional)	(000,0 ... 999,9 L/min)	$30,30,30,30_H$ ... $39,39,39,39_H$
4 Bytes	Actual flow rate ext.2 in L/min (Type 3 resp. 4)	
(optional)	(000,0 ... 999,9 L/min)	$30,30,30,30_H$ ... $39,39,39,39_H$
4 Bytes	Actual flow rate ext.3 in L/min(Type 3 resp. 4)	
(optional)	(000,0 ... 999,9 L/min)	$30,30,30,30_H$ ... $39,39,39,39_H$
4 Bytes	Actual flow rate ext.4 in L/min (Type 3 resp. 4)	
(optional)	(000,0 ... 999,9 L/min)	$30,30,30,30_H$ ... $39,39,39,39_H$
4 Bytes	Actual flow rate ext.5 in L/min (Type 3 resp. 4)	
(optional)	(000,0 ... 999,9 L/min)	$30,30,30,30_H$ ... $39,39,39,39_H$
4 Bytes	Actual flow rate ext.6 in L/min (Type 3 resp. 4)	
(optional)	(000,0 ... 999,9 L/min)	$30,30,30,30_H$ ... $39,39,39,39_H$
4 Bytes	Actual flow rate ext.7 in L/min (Type 3 resp. 4)	
(optional)	(000,0 ... 999,9 L/min)	$30,30,30,30_H$ ... $39,39,39,39_H$
4 Bytes	Actual flow rate ext.8 in L/min (Type 3 resp. 4)	
(optional)	(000,0 ... 999,9 L/min)	$30,30,30,30_H$ ... $39,39,39,39_H$
4 Bytes	Actual return line ext.1 in °C (Type 3 resp. 4)	
(optional)	(-99,9 ... -00,1 °C)	$2D,39,39,39_H$ ... $2D,30,30,31_H$
	(000,0 ... 999,9 °C)	$30,30,30,30_H$ ... $39,39,39,39_H$
4 Bytes	Actual return line ext.2 in °C (Type 3 resp. 4)	
(optional)	(-99,9 ... -00,1 °C)	$2D,39,39,39_H$ ... $2D,30,30,31_H$
	(000,0 ... 999,9 °C)	$30,30,30,30_H$ ... $39,39,39,39_H$
4 Bytes	Actual return line ext.3 in °C (Type 3 resp. 4)	
(optional)	(-99,9 ... -00,1 °C)	$2D,39,39,39_H$ ... $2D,30,30,31_H$
	(000,0 ... 999,9 °C)	$30,30,30,30_H$ ... $39,39,39,39_H$
4 Bytes	Actual return line ext.4 in °C (Type 3 resp. 4)	
(optional)	(-99,9 ... -00,1 °C)	$2D,39,39,39_H$ ... $2D,30,30,31_H$
	(000,0 ... 999,9 °C)	$30,30,30,30_H$ ... $39,39,39,39_H$
4 Bytes	Actual return line ext.5 in °C (Type 3 resp. 4)	
(optional)	(-99,9 ... -00,1 °C)	$2D,39,39,39_H$ ... $2D,30,30,31_H$
	(000,0 ... 999,9 °C)	$30,30,30,30_H$ ... $39,39,39,39_H$

4 Bytes	Actual return line ext.6 in °C (Type 3 resp. 4)	
(optional)	(-99,9 ... -00,1 °C)	$2D,39,39,39_H$ ... $2D,30,30,31_H$
	(000,0 ... 999,9 °C)	$30,30,30,30_H$ ... $39,39,39,39_H$
4 Bytes	Actual return line ext.7 in °C (Type 3 resp. 4)	
(optional)	(-99,9 ... -00,1 °C)	$2D,39,39,39_H$ ... $2D,30,30,31_H$
	(000,0 ... 999,9 °C)	$30,30,30,30_H$ ... $39,39,39,39_H$
4 Bytes	Actual return line ext.8 in °C (Type 3 resp. 4)	
(optional)	(-99,9 ... -00,1 °C)	$2D,39,39,39_H$ ... $2D,30,30,31_H$
	(000,0 ... 999,9 °C)	

[1)] At controller type units always 1

[2)] At controller type units always 0, but common alarm is set

3.6 Example of a Data Transfer for Unit with Address No. 1

Set data:		**Actual data:**	
Set temperature	95 °C	Actual temperature	95,0 °C
Operating mode	controlling	Actual flow rate	8,0 L/min
		Actual flow rate ext.1	1,7 L/min
		Actual flow rate ext.2	0,5 L/min
		Actual flow rate ext.3	1,2 L/min
		Actual flow rate ext.4	0,8 L/min
		Actual flow rate ext.5	0,4 L/min
		Actual flow rate ext.6	1,0 L/min
		Actual flow rate ext.7	0,6 L/min
		Actual flow rate ext.8	1,8 L/min
		Actual return line ext.1	93,9 °C
		Actual return line ext.2	91,3 °C
		Actual return line ext.3	93,4 °C
		Actual return line ext.4	92,7 °C
		Actual return line ext.5	90,3 °C
		Actual return line ext.6	93,1 °C
		Actual return line ext.7	91,9 °C
		Actual return line ext.8	94,0 °C
		Power output	23 %
		Remote mode	machine
		Heat sensor mode	internal
		Alarm	none
		Operating mode	controlling

Example of the Master Message

Description	**Standard**	**With flow rate internal**		**With flow rate internal an external an return line external**	
		Type 1	*Type 2*	*Type 3*	*Type 4*
Unit No. 1	$B1_H$	$B1_H$	$B1_H$	$B1_H$	$B1_H$
Block length 14 bytes	30_H, 30_H, $3E_H$	30_H, 30_H, $3E_H$	30_H, 30_H, $3E_H$	30_H, 30_H, $3E_H$	30_H, 30_H, $3E_H$
Record name	41_H	41_H	71_H	61_H	41_H
Set temperature 95 °C	30_H, 39_H, 35_H, 30_H	30_H, 39_H, 35_H, 30_H	30_H, 39_H, 35_H, 30_H	30_H, 39_H, 35_H, 30_H	30_H, 39_H, 35_H, 30_H
Reserve	60_H	60_H	60_H	60_H	60_H
Operating mode 'controlling'	72_H	72_H	72_H	72_H	72_H
Reserve	20_H	21_H	20_H	20_H	22_H
Checksum	35_H, 30_H	35_H, 31_H	38_H, 30_H	37_H, 30_H	35_H, 32_H

Example of the Slave Answer

Description	Standard	With flow rate internal		With flow rate internal an external an return line external	
		Type 1	*Type 2*	*Type 3*	*Type 4*
Unit No. 1	31_H	31_H	31_H	31_H	31_H
Block length 19 (23) bytes	30_H, 31_H, 33_H	30_H, 31_H, 37_H	30_H, 31_H, 37_H	30_H, 35_H, 37_H	30_H, 35_H, 37_H
Record name	41_H	41_H	71_H	61_H	41_H
Actual temperature 95 °C	30_H, 39_H, 35_H, 30_H	30_H, 39_H, 35_H, 30_H	30_H, 39_H, 35_H, 30_H	30_H, 39_H, 35_H, 30_H	30_H, 39_H, 35_H, 30_H
Power output 23 %	30_H, 30_H, 32_H, 33_H	30_H, 30_H, 32_H, 33_H	30_H, 30_H, 32_H, 33_H	30_H, 30_H, 32_H, 33_H	30_H, 30_H, 32_H, 33_H
Actual flow rate 8 L/min	-	30_H, 30_H, 38_H, 30_H	-	-	30_H, 30_H, 38_H, 30_H
Remote mode machine Heat sensor mode internal	62_H	62_H	62_H	62_H	62_H
Alarm 1 none	40_H	40_H	40_H	40_H	40_H
Alarm 2 none	40_H	40_H	40_H	40_H	40_H
Operating mode 'controlling'	72_H	72_H	72_H	72_H	72_H
Actual flow rate 8 L/min	-	-	30_H, 30_H, 38_H, 30_H	30_H, 30_H, 38_H, 30_H	-
Actual flow rate ext. 1 1,7 L/min	-	-	-	30_H, 30_H, 31_H, 37_H	30_H, 30_H, 31_H, 37_H
Actual flow rate ext. 2 0,5 L/min	-	-	-	30_H, 30_H, 30_H, 35_H	30_H, 30_H, 30_H, 35_H
Actual flow rate ext. 3 1,2 L/min	-	-	-	30_H, 30_H, 31_H, 32_H	30_H, 30_H, 31_H, 32_H
Actual flow rate ext. 4 0,8 L/min	-	-	-	30_H, 30_H, 30_H, 38_H	30_H, 30_H, 30_H, 38_H
Actual flow rate ext. 5 0,4 L/min	-	-	-	30_H, 30_H, 30_H, 34_H	30_H, 30_H, 30_H, 34_H
Actual flow rate ext. 6 1,0 L/min	-	-	-	30_H, 30_H, 31_H, 30_H	30_H, 30_H, 31_H, 30_H
Actual flow rate ext. 7 0,6 L/min	-	-	-	30_H, 30_H, 30_H, 36_H	30_H, 30_H, 30_H, 36_H
Actual flow rate ext. 8 1,8 L/min	-	-	-	30_H, 30_H, 31_H, 38_H	30_H, 30_H, 31_H, 38_H
Actual return line ext. 1 93,9 °C	-	-	-	30_H, 39_H, 33_H, 39_H	30_H, 39_H, 33_H, 39_H
Actual return line ext. 2 91,3 °C	-	-	-	30_H, 39_H, 31_H, 33_H	30_H, 39_H, 31_H, 33_H
Actual return line ext. 3 93,4 °C	-	-	-	30_H, 39_H, 33_H, 34_H	30_H, 39_H, 33_H, 34_H
Actual return line ext. 4	-	-	-	30_H, 39_H, 32_H,	30_H, 39_H, 32_H,

Description	Standard	With flow rate internal		With flow rate internal an external an return line external	
92,7 °C				37_H	37_H
Actual return line ext. 5 90,3 °C	-	-	-	30_H, 39_H, 30_H, 33_H	30_H, 39_H, 30_H, 33_H
Actual return line ext. 6 93,1 °C	-	-	-	30_H, 39_H, 33_H, 31_H	30_H, 39_H, 33_H, 31_H
Actual return line ext. 7 91,4 °C	-	-	-	30_H, 39_H, 31_H, 34_H	30_H, 39_H, 31_H, 34_H
Actual return line ext. 8 94,0 °C	-	-	-	30_H, 39_H, 34_H, 30_H	30_H, 39_H, 34_H, 30_H
Checksum	$3E_H$, $3D_H$	$3B_H$, 39_H	$3E_H$, 39_H	38_H, 31_H	36_H, 31_H

Communication shown with ASCII-Characters

Master-message: 0 0 > A 0 9 5 0 ' r 50

Slave-answer: 1 0 1 3 A 0 9 5 0 0 0 2 3 b @ @ r > =