TWC 9000 Supplementary instructions

Signal converter for mass flowmeters

Description of Modbus interface

Electronic Revision: ER 3.3.xx (SW.REV. 3.3x)
Modbus version 1.0.x

The documentation is only complete when used in combination with the relevant documentation for the sensor.

Honeywell

1 Important information 3

2 Technical data 5

2.1 General technical data 5
2.2 Technical data of the Modbus interface (acc. to EIA standards) 5

3 Connection in bus systems 7

4 Local configuration 9

5 Electrical connection 11

6 Modbus protocol 13

6.1 General information concerning the protocol 13
6.2 RTU frame format 13
6.3 Addressing 14
6.4 Overview of supported functions 14
6.5 Device identification on the Modbus interface 15
6.6 Coil registers 15
6.6.1 Converter controls 15
6.6.2 Counter controls 16
6.6.3 Start calibration functions 16
6.7 Input registers 17
6.8 Holding registers 18
6.8.1 Counter parameters 18
6.8.2 Process input filter parameters 19
6.8.3 Modbus parameters 21
6.9 Diagnostics 21
6.10 Calibration procedures 22
6.10.1 Zero Calibration 22
6.10.2 Manual Density Calibration 23
6.10.3 Single Point Density Calibration 24
6.10.4 Two Point Density Calibration 25

The flow converter with the RS485 interface card fitted, is able to communicate with an external device (PC or other suitable computer system) using the Modbus protocol. This option allows data exchange between PC or computer and single or multiple devices.

The bus configuration consists of one external device as a master and one or more converters as slaves. For bus operation the device address (menu C6.8.1), baudrate (menu C6.8.2) and settings (menu C6.8.3, C6.8.4, C6.8.5 & C6.8.6) must be set in the converter.

All devices connected to the bus, must have different unique addresses but the same baud rate and settings.

2.1 General technical data

Interface	RS485, galvanically isolated
Baud rate	1200, 2400, 4800, 9600, 19200, 38400, 57600 or 115200
Protocol	Modbus RTU (available as a separate document on request)
Maximum participants on bus	32 per line, master included (may be extended by repeaters)
Coding	NRZ bit coding
Address range	Modbus: 1...247
Transmission procedure	Half duplex, asynchronous
Bus access	Master / slave
Cable	Screened twisted pair
Distances	Maximum 1.2 km / 3937 ft without repeater (dependant on baud rate and cable specifications)

2.2 Technical data of the Modbus interface (acc. to EIA standards)

Kind of signal transmission	Differential, 2-wire topology
Maximum number of transmitter/receivers	32
Voltage range on converter input	-7...+12 V
Maximum voltage on converter output	5 V
Minimum voltage on driver output, max. load	U_{diff} > 1.5 V
Maximum input current (off state)	-20...+20 µA
Receiver input voltage	-7...+12 V
Sensitivity of the receiver	-200...+200 mV
Receiver input resistance	> 12 kΩ
Short circuit current	< 250 mA
Termination / polarization resistors (if activated by the jumpers X5/X6)	120 Ω / 560 Ω

For proper operation of Modbus in half duplex mode in single or multi-drop communication, it is recommended that a termination resistor is applied to both ends of the data line. The simplest form of termination is line-to-line resistor across the differential input.

In RTU mode the Modus protocol requires quiet periods on the communications bus for synchronisation. It is therefore important that the Modbus is not allowed to "float", i.e. unreferenced to 0 V, as this could lead to spurious signals due to noise pick-up. It is therefore necessary to employ biasing resistors at one point on the bus network, normally the "end".

The Modbus converter has two conditions. Default is without termination and polarization. To get the active termination and polarization the settings of jumper X5 and X6 on Modbus board must be changed then. For detailed information see chapter "Electrical Connection".

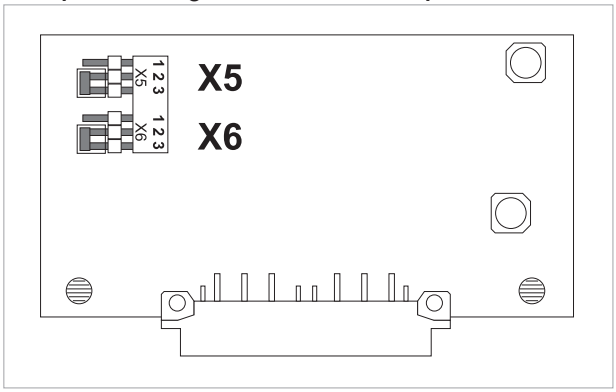
Converter Fct. No.	Display	Description and settings
C6.8.1	Slave Address	Selects the Modbus address of the device. Range: 1..247 (default = 1)
C6.8.2	Baud Rate	Selects the baud rate of the device. Options: 1200 / 2400 / 3600 / 4800 / 9600 / 19200 (default) / 38400 / 57600 / 115200
C6.8.3	Parity	Selects the parity. Options: Even (default) / Odd / No
C6.8.4	Data Format	Selects the data format. Options: Big Endian (default) / Little Endian
C6.8.5	Transmission Delay	Selects the delay between receiving the last byte of a request and sending the first byte of the response. Range: 0..40ms (default = 0ms)
C6.8.6	Stop Bits	Selects the number of stop bits. Options: 1 (default) / 2
C6.8.7	Information	Displays information about the device.

Terminals A and B of the converter are dependant on the options selected at order. Refer to the standard handbook of the converter for connection details.

Modbus connections

Terminals	Description
D-	Signal A (D 0)
D	Signal B (D 1)
C-	Common 0 V
C	Not connected

Jumper settings on the Modbus printed circuit board



Jumper position		Description
X5	X6	
1-2	1-2	With termination and polarization
2-3	2-3	Without termination and polarization

6.1 General information concerning the protocol

Using RTU (Remote Terminal Unit) format, data is transmitted as 8 bit binary characters. There are no special characters to determine the start and end of a message frame.

Synchronization is achieved by a minimum silent period of at least 3.5 character times before the start of each frame transmission and a maximum silent period of 1.5 character times between characters in the same frame.

6.2 RTU frame format

The format of the query and response frames vary slightly depending upon the command function. The basic form is outlined below.

Command function	Frame format	Description
Silent period	3.5 x T	All transmissions must be preceded by a minimum silent period of 3.5 x T, where T is the transmission time of a single character. This can be calculated from the baud rate, e.g. at 19.2 kb no parity with 1 stop bit (10 bits), T = 520 µs.
Slave address	8 bits	This is a single byte slave address which is transmitted first and must be in the range of 1...247. Address 0 is reserved for a broadcast address which all slaves should recognize, and therefore requires no response.
Function code	8 bits	This is an eight bit code in the range of 1...255 although only 126 functions exist as the codes 129...255 represent an error condition. An error condition occurs when the addressed slave does not accept the command, in which case it responds with the function code + 128, i.e. with its MSB set to 1.
Register start address or byte count when required	8 bit byte count 16 bit address	**Register start address:** for a query command that requires data to be returned, this field will contain the 16 bit start address of the register (or data) to be returned. Note that the converter uses protocol addresses. Therefore the register address listed is the actual number required in the Modbus command. **E.g:** to access input register 30006, the register start address is 30006dec = 7536hex. **Byte count:** In general this is only present in frames that are transferring data, and has a value equal to the number of bytes contained in the data field. The data field is limited to a maximum of 250 bytes.
Number of points or data bytes when required	n × 8 bits	**Number of points:** for a query command that requires data to be returned, this field will contain the number of registers to be returned regardless of their bit size. **Data bytes:** contains the data requested. The converter can use big endian format (MSB first) or little endian format (LSB first).
CRC	16 bits	This field contains a 16 bit CRC which is calculated on all the data bits of the message bytes.

6.3 Addressing

In the following tables the Modbus protocol addresses / data addresses are listed.

Some systems cannot use addresses above 9999. For these systems there is the possibility to use the listed addresses but

- for Input Registers omit the leading 3 of 3xxxx;
- for Holding Registers omit the leading 4 of 4xxxx;
- for Input Registers replace the leading 20 of 20xxx by 9xxx.

Sometimes register numbers are asked for. The **register numbers** can be calculated by adding a 1 to the protocol address and using a prefix according to the block:

- prefix 1 for coils
- prefix 3 for Input Registers
- prefix 4 for Holding Registers

6.4 Overview of supported functions

The following table shows Modbus functions supported by RS485 interface.

Function code		Name	Access to
hex	dec		
01	01	Read Single Coil	Status of calibration functions, counter status (start/stop)
03	03	Read Holding Register	Converter configuration parameter
04	04	Read Input Register	Measurement values, status values and calibration results
05	05	Write Single Coil	Cold start, warm start, error reset, start calibration function, start/stop counter
08	08	Diagnostics	-
10	16	Write Multiple Register	Converter configuration parameter

6.5 Device identification on the Modbus interface

The device identification is according to the category "Regular" according to the Modbus Application Protocol Specification V1.1a. Function code 43 / 14 (0x2B / 0x0E).

Modbus object Id	Object name / Description	Type	Content
0x00	VendorName	16 byte ASCII String	HONEYWELL
0x01	ProductCode	10 byte ASCII String	CG number; order code for the converter assembly
0x02	MajorMinorRevision	7 byte ASCII String	V1.0.00
0x03	Vendor URL	32 byte ASCII String	www.honeywell.com
0x04	ProductName	16 byte ASCII String	TWC9000
0x05	ModelName	16 byte ASCII String	Modbus
0x06	UserApplicationName	16 byte ASCII String	User tag, displayed on the header of the local screen

6.6 Coil registers

These function codes are used for access:

- 0x01 = read input coil
- 0x05 = write single coil

6.6.1 Converter controls

Coil address	Function
1000	Write 1 generates a cold start, write 0 is ignored
1001	Write 1 generates a warm start, write 0 is ignored
1002	Write 1 generates an error reset, write 0 is ignored

6.6.2 Counter controls

Modbus protocol address	Description	Settings			Converter Fct. No.
3000	Start / Stop Counter 1	Write	1	start counter	C4.1.8 / C4.1.9
		Write	0	stop counter	
		Read	1	counter is running	
		Read	0	counter is stopped	
3001	Start / Stop Counter 2	Write	1	start counter	C4.2.8 / C4.2.9
		Write	0	stop counter	
		Read	1	counter is running	
		Read	0	counter is stopped	
3002	Start / Stop Counter 3 ①	Write	1	start counter	C4.3.8 / C4.3.9
		Write	0	stop counter	
		Read	1	counter is running	
		Read	0	counter is stopped	
3003	Reset Counter 1	Write	1	reset counter	C4.1.6
		Write	0	-	
		Read	0	-	
3004	Reset Counter 2	Write	1	reset counter	C4.2.6
		Write	0	-	
		Read	0	-	
3005	Reset Counter 3 ①	Write	1	reset counter	C4.3.6
		Write	0	-	
		Read	0	-	

① Only available in converters with IO2. A write attempt to a non-existing counter will cause an error response.

6.6.3 Start calibration functions

Modbus protocol address	Description	Settings			Converter Fct. No.
2000	Zero Calibration	Write	1	start function	C1.1.1
		Write	0	-	
		Read	0	-	
2001	Single Point Density Calibration	Write	1	start function	C1.2.1
		Write	0	-	
		Read	0	-	
2002	Two Point Density Calibration - first calibration point	Write	1	start function	C1.2.1
		Write	0	-	
		Read	0	-	
2003	Two Point Density Calibration - second calibration point	Write	1	start function	C1.2.1
		Write	0	-	
		Read	0	-	

6.7 Input registers

Measurement and status values are read only and can be accessed as Modbus "Input Registers".

Also the result of a calibration procedure is accessed by an input register at Modbus Protocol Address 20000. The type are one or more float values.

Function code is 04 (0x04).

Modbus protocol address	Description and settings	Type	Number of registers
30000	**Flow Velocity** [m/s]	float	2
30002	**Volume Flow** [m^3/s]	float	2
30004	**Mass Flow** [kg/s]	float	2
30006	**Temperature** [K]	float	2
30008	**Density** [kg/m^3]	float	2
30010	**Concentration 1**	float	2
30012	**Concentration 2 or Diagnosis 3**	float	2
30014	**Concentration Flow 1**	float	2
30016	**Concentration Flow 2**	float	2
30018	**Diagnosis 1**	float	2
30020	**Diagnosis 2**	float	2
30022	**Display Channel 1** Represents the value on the first line of the first measurement screen in SI units	float	2
30024	**Display Channel 2** Represents the value on the first line of the second measurement screen in SI units	float	2
30026	**Operating time** [s]	float	2
30050	**Counter 1** [m^3] or [kg]	double float	4
30054	**Counter 2** [m^3] or [kg]	double float	4
30058	**Counter 3** [m^3] or [kg] Note: this counter is only available for converter with IO2!	double float	4
30062	**Long Status Sensor**	byte [4]	2
30064	**Long Status Device**	byte [4]	2

6.8 Holding registers

Some parameters of the device can be accessed as Modbus holding registers.

Function code 03 (0x03) for "Read" operations and function code 16 (0x10) for "Write" operations.

The holding registers are grouped into the following different sections.

6.8.1 Counter parameters

INFORMATION!
Counter 3 parameters are only available for converter with IO2.

Modbus protocol address	Description and settings	Converter Fct. No.	Type	Number of registers
40000	**Counter 1 Function** 1 = Sum Counter 2 = + Counter 3 = - Counter 0 = Off	C4.1.1	byte	1
40001	**Measurement Counter 1** 21 = Volume Flow 22 = Mass Flow 27 = Concentration Flow 1 28 = Concentration Flow 2	C4.1.2	word	1
40002	**Counter 2 Function** 1 = Sum Counter 2 = + Counter 3 = - Counter 0 = Off	C4.2.1	byte	1
40003	**Measurement Counter 2** 21 = Volume Flow 22 = Mass Flow 27 = Concentration Flow 1 28 = Concentration Flow 2	C4.2.2	word	1
40004	**Counter 3 Function** 1 = Sum Counter 2 = + Counter 3 = - Counter 0 = Off	C4.3.1	byte	1
40005	**Measurement Counter 3** 21 = Volume Flow 22 = Mass Flow 27 = Concentration Flow 1 28 = Concentration Flow 2	C4.3.2	word	1
41000	**Low Flow Cutoff Value Counter 1** [m^3/s] or [kg/s]	C4.1.3	float	2
41002	**Time Constant Counter 1** [s]	C4.1.4	float	2
41004	**Set Counter 1 or Read Counter 1** [m^3] or [kg]	C4.1.7	float	2
41006	**Low Flow Cutoff Value Counter 2** [m^3/s] or [kg/s]	C4.2.3	float	2
41008	**Time Constant Counter 2** [s]	C4.2.4	float	2
41010	**Set Counter 2 or Read Counter 2** [m^3] or [kg]	C4.2.7	float	2

Modbus protocol address	Description and settings	Converter Fct. No.	Type	Number of registers
41012	**Low Flow Cutoff Value Counter 3** [m^3/s] or [kg/s]	C4.3.3	float	2
41014	**Time Constant Counter 3** [s]	C4.3.4	float	2
41016	**Set Counter 3 or Read Counter 3** [m^3] or [kg]	C4.3.7	float	2
41018	**Preset Counter 1** [m^3] or [kg]	C4.1.5	float	2
41020	**Preset Counter 2** [m^3] or [kg]	C4.2.5	float	2
41022	**Preset Counter 3** [m^3] or [kg]	C4.3.5	float	2

6.8.2 Process input filter parameters

Modbus protocol address	Description and settings	Converter Fct. No.	Type	Number of registers
42000	**Select Concentration 1** 1 = Off 2 = Brix 3 = % Mass 4 = Baume 144 5 = Baume 145 6 = % NaOH 7 = Plato 8 = API 9 = % Volume	C2.2.1	byte	1
42001	**Select Concentration 2** 1 = Off 2 = Brix 3 = % Mass 4 = Baume 144 5 = Baume 145 6 = % NaOH 7 = Plato 8 = API 9 = % Volume	C2.3.1	byte	1
42002	**Select Diagnosis 1** 9 = Tube Frequency [Hz] 10 = Measuring Tube Strain [Ω] 11 = Inner Cylinder Strain [Ω] 14 = Drive Energy [%] 31 = Sensor Average [%] 32 = Sensor Deviation [%] 255 = Off	C1.5.4	byte	1
42003	**Select Diagnosis 2** 9 = Tube Frequency [Hz] 10 = Measuring Tube Strain [Ω] 11 = Inner Cylinder Strain [Ω] 14 = Drive Energy [%] 31 = Sensor Average [%] 32 = Sensor Deviation [%] 255 = Off	C1.5.5	byte	1
42004	**Select Diagnosis 3** 9 = Tube Frequency [Hz] 10 = Measuring Tube Strain [Ω] 11 = Inner Cylinder Strain [Ω] 14 = Drive Energy [%] 31 = Sensor Average [%] 32 = Sensor Deviation [%] 255 = Off	C1.5.6	byte	1

Modbus protocol address	Description and settings	Converter Fct. No.	Type	Number of registers
43000	**Zero Calibration Value**	C1.1.1	float	2
43002	**Zero Calibration Temperature**	C1.1.1	float	2
43004	**DCF2**	C1.2.1	float	2
43006	**DCF3**	C1.2.1	float	2
43008	**DCF4**	C1.2.1	float	2
43010	**DCF6**	C1.2.1	float	2
43012	**DCF7**	C1.2.1	float	2
43014	**DCF8**	C1.2.1	float	2
44000	**Density Calibration State** 0 = First Calibration Point Not Done 1 = First Calibration Point Done	C1.2.1	byte	1
44001	**DCF1** 0 = Empty 1 = Pure Water 2 = Town Water 3 = Other	C1.2.1	byte	1
44002	**DCF5** 0 = Empty 1 = Pure Water 2 = Town Water 3 = Other	C1.2.1	byte	1

6.8.3 Modbus parameters

Modbus protocol address	Description and settings	Converter Fct. No.	Type	Number of registers
50000	**Baud Rate** 1200 / 2400 / 3600 / 4800 / 9600 / 19200 (default) / 38400 / 57600 / 115200	C6.8.2	ulong	2
50002	**Slave Address**	C6.8.1	byte	1
50003	**Parity** 0 = Even Parity (default) 1 = Odd Parity 3 = No Parity	C6.8.3	byte	1
50004	**Data Format** 0 = Little Endian (MSB first) 1 = Big Endian (LSB first)	C6.8.4	byte	1

6.9 Diagnostics

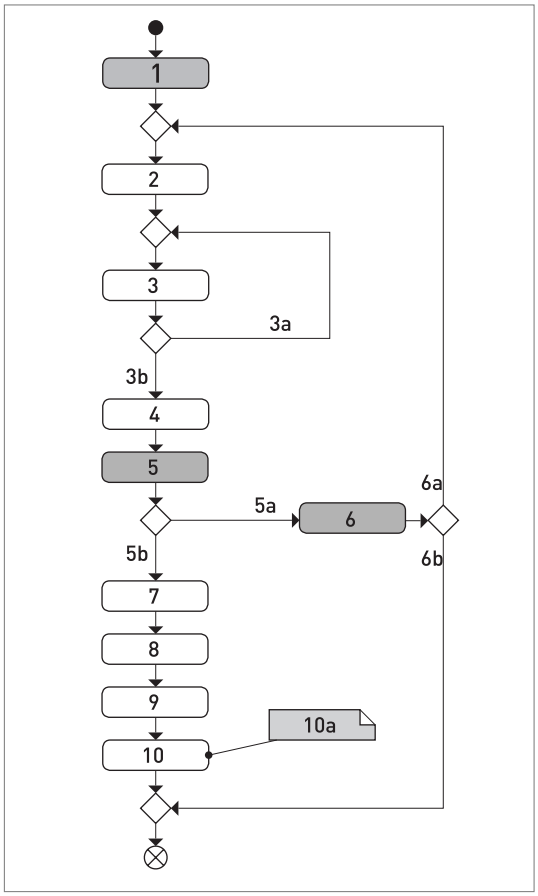
The Modbus interface supports the diagnostic function defined by the "Modbus Application Protocol Specification".

Function code is 08 (0x08).

Sub function code		Name
hex	dec	
00	00	Return Query Data
01	01	Restart Communication Option
04	04	Force Listen Only Mode
0A	10	Clear Counters
0B	11	Return Bus Message Count
0C	12	Return Bus Communication Error Count
0D	13	Return Bus Exception Count
0E	14	Return Slave Message Count
0F	15	Return Slave No Response Count
10	16	Return Slave NAK Count (counter not used)
11	17	Return Slave Busy Count (counter not used)
12	18	Return Bus Character Overrun Count

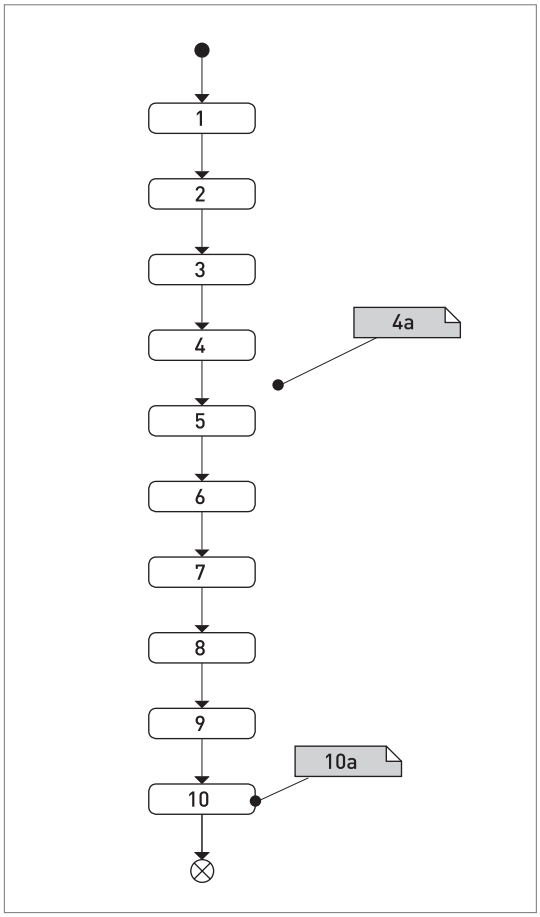
6.10 Calibration procedures

6.10.1 Zero Calibration



1	**User reduces the actual flow through the meter to zero**
2	**Start zero calibration:** Set single coil 2000 to 1 (Modbus Fct. 0x05)
3	**Check status of calibration** Read single coil 2000 (Modbus Fct. 0x01)
3a	[2000 == 1: calibration running]
3b	[2000 == 0: calibration complete]
4	**Read Calibration Value** Read Input Register 20000 type float (Modbus Fct. 0x04)
5	**User checks the calibration value:** -10...+10: acceptable result
5a	Not ok
5b	ok
6	**User tries to improve the calibration situation**
6a	Improvement done
6b	Improvement not possible -Break-
7	**Write the calibration value** Write Holding Register 43000 type float (Modbus Fct. 0x10)
8	**Read Calibration Temperature** Read Input Register 20002 type float (Modbus Fct. 0x04)
9	**Write Calibration Temperature** Write Holding Register 43002 type float (Modbus Fct. 0x10)
10	**Activate new values** Set single coil 1001 to 1 (Modbus Fct. 0x05)
10a	This results in a warm start of the device. Will take maximum 5s.

6.10.2 Manual Density Calibration



1 **Write DCF1 value**
Write Holding Register 44001 type byte
(Modbus Fct. 0x10)

2 **Write DCF2 value**
Write Holding Register 43004 type float
(Modbus Fct. 0x10)

3 **Write DCF3 value**
Write Holding Register 43006 type float
(Modbus Fct. 0x10)

4 **Write DCF4 value**
Write Holding Register 43008 type float
(Modbus Fct. 0x10)

4a All DCF Values have to be used from Calibration Certificate!

5 **Write DCF5 value**
Write Holding Register 44002 type byte
(Modbus Fct. 0x10)

6 **Write DCF6 value**
Write Holding Register 43010 type float
(Modbus Fct. 0x10)

7 **Write DCF7 value**
Write Holding Register 43012 type float
(Modbus Fct. 0x10)

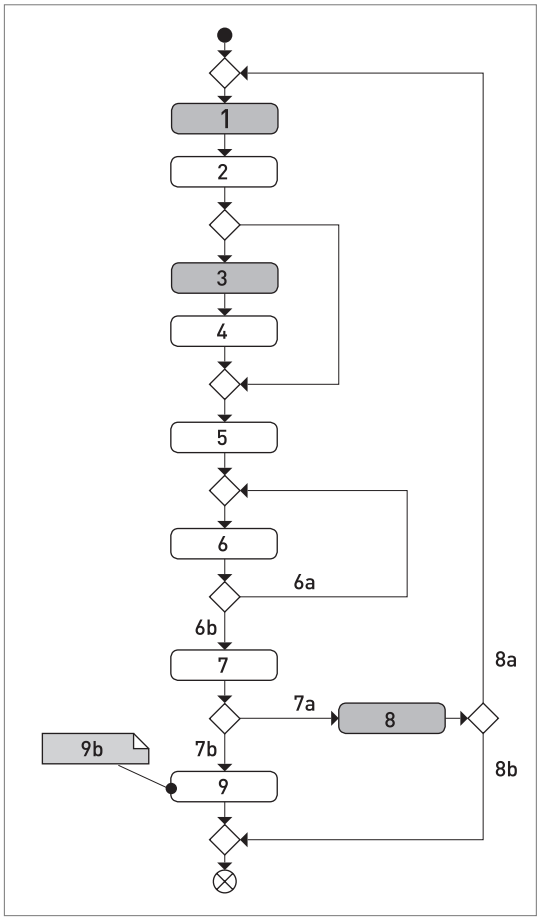
8 **Write DCF8 value**
Write Holding Register 43014 type float
(Modbus Fct. 0x10)

9 **Write Calibration State = 0**
Write Holding Register 44000 type byte
(Modbus Fct. 0x10)

10 **Activate new values**
Set single coil 1001 to 1 (Modbus Fct. 0x05)

10a This results in a warm start of the device.
Will take maximum 5s.

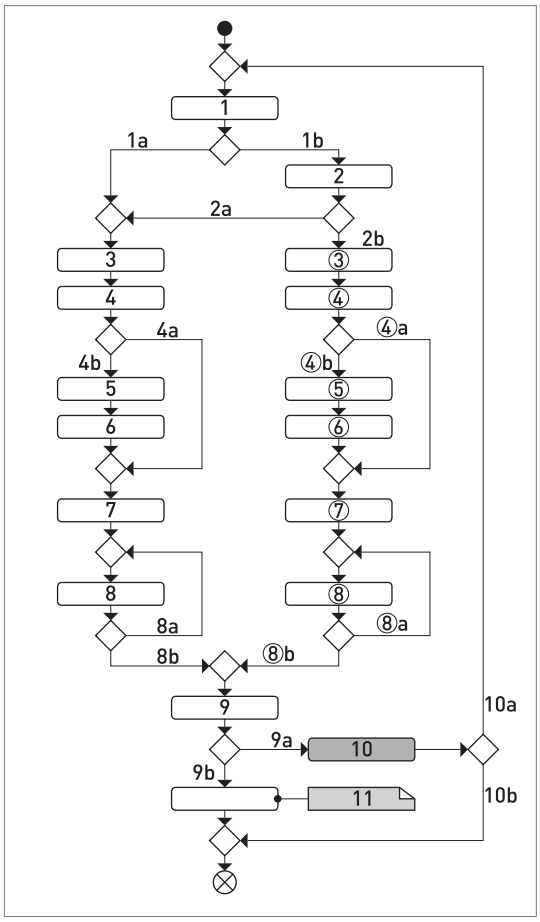
6.10.3 Single Point Density Calibration



1	**User selects actual density type:** 0: Empty; 1: pure water; 2: town water; 3: other
2	**Write DCF1 value (density type):** Write Holding Register 44001 type byte (Modbus Fct. 0x10)
3	**User enters actual density value:**
4	**Write DCF2 value (density value in kg/m^3)**: Write Holding Register 43004 type float (Modbus Fct. 0x10)
5	**Start density calibration:** Set single coil 2001 to 1 (Modbus Fct. 0x05)
6	**Check status of calibration:** Read single coil 2001 (Modbus Fct. 0x01)
6a	[2001 = 1: calibration running]
6b	[2001 = 0: calibration complete]
7	**Read Calibration Result** Read Input Register 20000 type byte (Modbus Fct. 0x04)
7a	[20000 = 1: fail]
7b	[20000 = 0: pass]
8	**User tries to improve the calibration situation**
8a	Improvement done
8b	Improvement not possible - Break-
9	**Activate new values** Set single coil 1001 to 1 (Modbus Fct. 0x05)
9b	This results in a warm start of the device. Will take maximum 5s.

6.10.4 Two Point Density Calibration

After first calibration pint, fluid inside the meausing sensor must be changed and the calibration procedure started again.



1	**Read densisty calibration status:** Read Holding Register 44000 type byte (Modbus Fct. 0x03)
1a / 1b	[status = 0] / [status = 1]
2	**User selects calibration point:**
2a	Repeat 1st calibration point
2b	Start 2nd calibration point
3 & ③	**User selects actual density type:** 0: Empty; 1: pure water; 2: town water; 3: other
4	**Write DCF1 value (density type):** Write Holding Register 44001 type byte (Modbus Fct. 0x10)
4a / 4b	[DCF1 <> 3: Not Other] / [DCF1 = 3: Other]
④	**Write DCF5 value (density type):** Write Holding Register 44002 type byte (Modbus Fct. 0x10)
④a	[DCF5 <> 3: Not Other]
④b	[DCF5 = 3: Other]
5 & ⑤	**User enters actual density value:**
6	**Write DCF2 value (density value in kg/m^3):** Write Holding Register 43004 type float (Modbus Fct. 0x10)
⑥	**Write DCF6 value (density value in kg/m^3):** Write Holding Register 43010 type float (Modbus Fct. 0x10)
7	**Start density calibration 1st point:** Set single coil 2002 to 1 (Modbus Fct. 0x05)
⑦	**Start density calibration 2nd point:** Set single coil 2003 to 1 (Modbus Fct. 0x05)
8	**Check status of calibration:** Read single coil 2002 (Modbus Fct. 0x01)
8a	[2002 = 1: calibration running]
8b	[2002 = 0: calibration complete]
⑧	**Check status of calibration:** Read single coil 2003 (Modbus Fct. 0x01)
⑧a	[2003 = 1: calibration running]
⑧b	[2003 = 0: calibration complete]
9	**Read Calibration Result** Read Input Register 20000 type byte (Modbus Fct. 0x04)
9a / 9b	[20000 = 1: fail] / [20000 = 0: pass]
10	**User tries to improve the calibration situation**
10a	Improvement done
10b	Improvement not possible -Break-
11	This results in a warm start of the device. Will take maximum 5s.

Honeywell Field Solutions
512 Virgina Drive
Fort Washington, PA 19034
www.honeywell.com/ps