LEVITRONIX CONSOLE MODBUS TCP/IP INTERFACE

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PURPOSE: MODBUS TCP/IP Interface description for LCO-xx consoles

SCOPE: LCO-i100, LCO-600, LCO-2000, LCO-4000

Contents:

1 Communication

Levitronix consoles support MODBUS TCP/IP over ethernet on port 502.

The client that initiates a MODBUS transaction builds the MODBUS Application Data Unit. This data unit consists of three parts: A header, the function code and the data part.

A header is used on TCP/IP to identify the MODBUS Application Data Unit. It is called the MBAP header (MODBUS Application Protocol header).

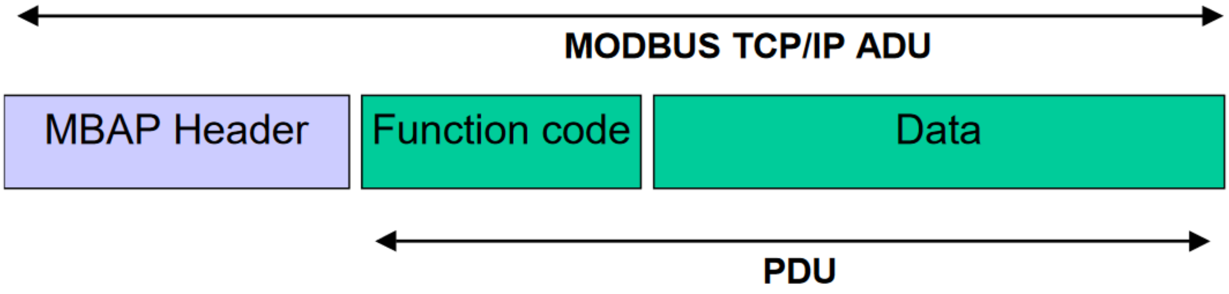


Figure 1: Structure of a MODBUS Application data unit

The MBAP header contains the following fields:

-**Transaction Identifier** (2 bytes): Used for transaction pairing, the MODBUS server copies in the response the transaction identifier of the request.

- **Protocol Identifier** (2 bytes): The modbus protocol is identified by the value 0.

- **Length** (2 bytes): the length field is a byte count of the following fields, including the units identifier and data fields.

- **Unit Identifier** (1 byte): used for intra-system routing purpose. (typically: 0)

The header is 7 bytes long.

The combination of function code and data is called *protocol data unit* (PDU).

The function code indicates to the server which kind of action to perform.

In the following description and examples only the PDU part (Function code and Data) is documented. For communication to the console the MBAP header must be added in front of the PDU part.

1.1 Supported MODBUS functions

Following MODBUS functions are supported by LEVIFLOW^{TM}

Function code	Description
03	Read Hold Registers
04	Read Input Registers
06	Write Single Hold Register
16	Write Multiple Hold Registers

A detailed description of the MODBUS protocol and its functions in general can be found here:

http://www.modbus.org/docs/Modbus_Messaging_Implementation_Guide_V1_0b.pdf

2 Input registers

Input registers are read-only. Modbus function 04 is used to read values of input registers.

2.1 Input register map

Address	Scaling Factor	Description	Unit	Notes
0	1	Console State	-	Console States: 0.. Console startup state 1.. Off state 2.. Speed control state 3.. Flow control state 4.. Pressure control state 5.. Forced speed control state, flowmeter disconnected while in flow control state 6.. Error state 7.. – 8.. Speed control output to pump with plc analog output set to value 9.. Speed control output to pump with flow control output set to plc anout 10.. Speed control output to pump with pressure control output set to plc anout 11.. Flow control output to pump with plc analog output set to value 12.. Flow control output to pump with pressure control output set to plc anout 13.. Pressure control output to pump with plc analog output set to value 14.. Pressure control output to pump with flow control output set to plc anout 15.. Pump Off with PLC analog output set to value 16.. Pump Off with flow control output to plc anout 17.. Pump Off with pressure control output to plc anout 18.. Custom control state 19.. Speed control output to pump with custom control output set to plc anout 20.. Flow control output to pump with custom control output set to plc anout 21.. Pressure control output to pump with custom control output set to plc anout 22.. Custom control output to pump with speed control output set to plc anout 23.. Custom control output to pump with flow control output set to plc anout 24.. Custom control output to pump with pressure control output set to plc anout 25.. Pump Off with custom control output to plc anout
1	1	Actual Speed	rpm	
2	1	Actual Flow (32-bit value, LSW)	mlpm	Actual flow in mlpm
3		Actual Flow (32-bit value, MSW)		
4	1	Actual Pressure 1	mbar	Actual pressure 1 in mbar
5	1	Actual Pressure 2	mbar	Actual pressure 2 in mbar
6	1	Actual Pressure 3	mbar	Actual pressure 3 in mbar
7	1	Actual Pressure AnIn	mbar	Actual pressure AnIn in mbar
8	1	Actual TM Pressure	mbar	Actual TM pressure in mbar TM pressure = (inlet pressure + outlet pressure) / 2 – permeate pressure
9	0.1	Actual Fluid Temperature	°C	Actual fluid temperature in °C
10	0.01	Actual Custom AnIn (32-bit value, LSW)	Unit	Actual custom AnIn in custom Unit
11		Actual Custom AnIn (32-bit value, MSW)		
12	0.1	Actual Flow Volume Counter Value (32-bit value, LSW)	mL	Actual flow volume counter value Max. value is 99999.9 mL, when volume has passed, counter restarts at 0.
13		Actual Flow Volume Counter Value (32-bit value, MSW)		
14	0.01	Actual PLC Analog Input	mA	PLC analog input in mA
15	1	Actual PLC Digital Inputs	-	Bit0: PLC digital input 1, Bit1: PLC digital input 2

16	0.01	Actual PLC Analog Output	mA	PLC analog output in mA
17	1	Actual PLC Digital Outputs	-	Bit0: PLC digital output 1, Bit1: PLC digital output 2
18	1	Actual Flow RS485 (32-bit value, LSW)	mlpm	Actual flow RS485 in mlpm
19		Actual Flow RS485 (32-bit value, MSW)		
20	1	Actual Delta P	mbar	Actual Delta P in mbar
21	0.1	Actual Flow RS485 Volume Counter Value (32-bit value, LSW)	mL	Actual flow RS485 volume counter value
22		Actual Flow RS485 Volume Counter Value (32-bit value, MSW)		
23	-	-	-	
24	-	-	-	
25	-	-	-	
26	-	-	-	
27	-	-	-	
28	1	Connected Peripherals	-	Bit0: Flowsensor connected Bit1: Pressure 1 connected Bit2: Pressure 2 connected Bit3: Pressure AnIn connected Bit4: TM Pressure connected Bit5: Temperature Sensor connected Bit6: PLC connected Bit7: Pressure 3 connected Bit8: Flow RS485 connected Bit9: Delta P connected
29	1	Active Recipe	-	0.. No recipe in progress 1.. Recipe 1 in progress 2.. Recipe 2 in progress 3.. Recipe 3 in progress 4.. Recipe 4 in progress 5.. Recipe 5 in progress 6.. Recipe 6 in progress 7.. Recipe 7 in progress 8.. Recipe 8 in progress 9.. Recipe 9 in progress 10.. Recipe 10 in progress 11.. Recipe 11 in progress 12.. Recipe 12 in progress 13.. Recipe 13 in progress 14.. Recipe 14 in progress 15.. Recipe 15 in progress 16.. Recipe 16 in progress 17.. Recipe 17 in progress 18.. Recipe 18 in progress 19.. Recipe 19 in progress 20.. Recipe 20 in progress
30	1	Recipe State	-	0.. Idle 1.. Phase A in progress 2.. Wait to finish phase A 3.. Phase B in progress 4.. Wait to finish phase B 5.. Phase C in progress 6.. Wait to finish phase C 7.. Phase D in progress 8.. Wait to finish phase D 9.. Phase E in progress 10.. Wait to finish phase E 11.. Phase F in progress 12.. Wait to finish phase F 13.. Phase G in progress 14.. Wait to finish phase G 15.. Phase H in progress 16.. Wait to finish phase H 17.. Phase I in progress 18.. Wait to finish phase I 19.. Phase J in progress 20.. Wait to finish phase J 21.. Recipe finished

31	1	Zero Adjustment State	-	Bit0: Flowmeter zero adjustment in progress Bit1: Pressure 1 zero adjustment in progress Bit2: Pressure 2 zero adjustment in progress Bit3: Pressure AnIn zero adjustment in progress Bit4: Custom AnIn zero adjustment in progress Bit5: Pressure 3 zero adjustment in progress Bit6: Flow RS485 zero adjustment in progress Bit7: - Bit8: Flowmeter zero adjustment error Bit9: Flow RS485 zero adjustment error
32	-	-	-	
33	-	-	-	
34	1	Active recipe run	-	Actual run of recipe
35	-	-	-	
36	-	-	-	
37	-	-	-	
38	-	-	-	
39	-	-	-	
40	-	-	-	
41	-	-	-	
42	-	-	-	
43	-	-	-	
44	1	Active Notifications N1-N16	-	N1, N3, N6: Pump not connected N4, N10: Internal pump error N5: Impeller stabilization failed N7: Supply voltage out of range N8: Console temperature too high N9: Pump temperature too high N11: Motortype not detected N12: Flowmeter disconnected while in flow control mode N13: Flow Measurement error N14: Flowmeter calibration parameter error N15: Flow zero adjustment error N16: Internal flowmeter error
45	1	Active Notifications N17-N32	-	N17, N18, N19, N20: Impeller stabilizing issues N21: Internal pump communication issues N22: Pump supply voltage out of range N23: Pump drive power limit reached N24: Dry running detected N25: High console temperature N26, N27, N28: High pump temperature N29: Speed out of tolerance N30: Flow out of tolerance N31: Pressure out of tolerance N32: USB memory full
46	1	Active Notifications N33-N48	-	N33: USB memory disconnected N34: Flow alarm low N35: Flow alarm high N36: Flowmeter bubble detected N37: Flow zero adjustment running N38: Auto-resume has recovered previous system state N39: Pressure 1 alarm low N40: Pressure 2 alarm high N41: Pressure 2 alarm low N42: Pressure 2 alarm high N43: Pressure AnIn alarm low N44: Pressure AnIn alarm high N45: Custom AnIn alarm low N46: Custom AnIn alarm high N47: Fluid temperature alarm low N48: Fluid temperature alarm high

47	1	Active Notifications N49-N64	-	N49: No pump firmware installed N50: Pressure 3 alarm low N51: Pressure 3 alarm high N52: TM Pressure alarm low N53: TM Pressure alarm high N54: Flow RS485 alarm low N55: Flow RS485 alarm high N56: Flow RS485 disconnected while in flow control mode N57: Flow RS485 measurement error N58: Flow RS485 calibration parameter error N59: Flow RS485 zero adjustment error N60: Internal flow RS485 error N61: Flow RS485 zero adjustment running N62: Flow RS485 bubble detected N63: No Flow RS485 firmware installed N64: --
48	1	Active Notifications N65-N80	-	N65-N75: reserved notifications N76: Delta P alarm low N77: Delta P alarm high N78: Serial pump network error N79: Custom control out of tolerance N80: Pressure sensor disconnected while in pressure control
49	-	-	-	
50	-	-	-	
51	-	-	-	
52	1	Pumpsystem Type	-	1.. Puralev-200SU 2.. Puralev-200MU 3.. Puralev-600SU 4.. Puralev-600MU 5.. Puralev-i30SU 6.. – 7.. Puralev-i100SU 8.. Puralev-i100MU 9.. Puralev-2000SU 10.. Puralev-2000MU 11.. Puralev-i600SU 12.. Puralev-i600MU 13.. Puralev-4000SU 14.. Puralev-4000MU
53	1	Flowmeter Type	-	1.. LFS-03SU 2.. LFS-06SU 3.. LFS-10SU 4.. LFS-15SU 5.. LFS-20SU 6.. – 7.. – 8.. – 9.. – 10.. – 11.. LFSC-05D 12.. LFSC-08D 13.. LFSC-12D 14.. LFSC-22D 15.. LFSC-27D 16.. LFSC-30D 17.. LFSC-32D 18.. Flowmeter undefined 43.. LFSC-06D 44.. LFSC-09D 45.. LFSC-11D 46.. LFSC-17D 47.. LFSC-23D 48.. LFSC-35D

54	1	Active Flowmeter Calibration Set	-	0.. Calibration set 1 active 1.. Calibration set 2 active 2.. Calibration set 3 active 3.. Calibration set 4 active 4.. Calibration set 5 active 5.. Calibration set 6 active 6.. Calibration set 7 active 7.. Calibration set 8 active
55	1	Flowmeter RS485 Type	-	49.. LFSC-i06X 50.. LFSC-i10X 51.. - 52.. LFSC-i14X 53.. - 54.. LFSC-i19X 55.. LFSC-i25X 56.. LFSC-i35X 57.. LFSC-i38X 58.. LFSC-i36X.1 59.. LFSC-i05X.1 60.. LFSC-i09X.1 61.. LFSC-i13X.1 62.. LFSC-i16X.1 63.. LFSC-i22X.1 64.. LFSC-i25X.1
56	1	Active Flowmeter RS485 Calibration Set	-	0.. Calibration set 1 active 1.. Calibration set 2 active 2.. Calibration set 3 active 3.. Calibration set 4 active 4.. Calibration set 5 active 5.. Calibration set 6 active 6.. Calibration set 7 active 7.. Calibration set 8 active
57	-	-	-	
58	-	-	-	
59	-	-	-	
60	-	-	-	
61	-	-	-	
62	-	-	-	
63	-	-	-	
64	-	-	-	
65	1	Console Software Version	-	16 Bytes ASCII string e.g. “LCO V1.04 R06”
66				
67				
68				
69				
70				
71				
72				
73	1	Pump Firmware Version	-	16 Bytes ASCII string e.g. “G100 G3.48 R02”
74				
75				
76				
77				
78				
79				
80				
81	1	Flowmeter Firmware Version	-	18 Bytes ASCII string e.g. “DSP: 18 / FPGA: 06”
82				
83				
84				
85				
86				
87				
88				
89				

90	1	Console Serialnumber	-	16 Bytes ASCII string e.g. “110118-2400”
91				
92				
93				
94				
95				
96				
97				

98	1	Pump Controller Serialnumber	-	16 Bytes ASCII string e.g. "200117-0021"
99				
100				
101				
102				
103				
104				
105				
106	1	Pump Motor Serialnumber	-	16 Bytes ASCII string e.g. "301116-0564"
107				
108				
109				
110				
111				
112				
113				
114	1	Flowmeter Converter Serialnumber	-	16 Bytes ASCII string e.g. "1CP17K077"
115				
116				
117				
118				
119				
120				
121				
122	-			
123	-			
124	-			
125	-			
126	-			
127	-			
128	-			
129	-			
130	-			
131	-			
132	-			
133	-			
134	-			
135	1	Flow RS485 Firmware Version	-	18 Bytes ASCII string e.g. "Ver: 0101"
136				
137				
138				
139				
140				
141				
142				
143				
144	1	Flow RS485 Serialnumber	-	16 Bytes ASCII string e.g. "IX1201172210"
145				
146				
147				
148				
149				
150				
151				

2.1.1 Example: Read Input register (MODBUS function 0x04)

In this example Input register 0, 1, 2, 3 are read.

→ Start Register 0 and Quantity of Registers = 4

MODBUS Request:

Function Code	Start Register		Quantity of Registers	
	MSB	LSB	MSB	LSB
0x04	**0x00**	**0x00**	**0x00**	**0x04**

MODBUS Response:

Function Code	Byte Count (Nr. of value bytes)	Register #1 Value		Register #2 Value		Register #3 Value		Register #4 Value	
		MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB
0x04	**0x08**	**0x00**	**0x02**	**0x23**	**0x35**	**0x11**	**0x66**	**0x00**	**0x00**

→	Input register 0:	Console State	0x0002h (Speed control state)
	Input register 1:	Actual speed	0x2335h = 9013 ≡ 9013 rpm
	Input register 2:	Actual flow (least significant word)	0x1166h
	Input register 3:	Actual flow (most significant word)	0x0000h
		→ Actual flow 0x00001166h = 4454	≡ 4454 mlpm

MODBUS Error Response:

Device ID	Function Code	Exception Code
0x01	**0x84**	

Exception Code: 02 Invalid Start Register

03 Invalid combination (Start Register + Quantity of Registers)

3 Hold registers

Hold registers are writable. MODBUS function 03 is used to read values of hold registers. MODBUS function 06 writes to a single register. Modbus function 16 can be used to write multiple registers.

3.1 Hold register map

Address	Scaling Factor	Description	Unit	Notes
0	1	State Request	-	1.. Pump off state 2.. Enable speed control 3.. Enable flow control 4.. Enable pressure control 5.. Enable plc anout control 6.. Disable plc anout control 7.. Enable custom control
1	1	Setpoint Speed	rpm	Setpoint speed in rpm
2	1	Setpoint Flow (32-bit value, LSW)	mlpm	Setpoint flow in mlpm
3		Setpoint Flow (32-bit value, MSW)		
4	1	Setpoint Pressure	mbar	Setpoint pressure in mbar
5	1	Setpoint PLC Analog Output (32-bit value, LSW)	Unit	Setpoint plc analog output (customizable unit)
6		Setpoint PLC Analog Output (32-bit value, MSW)		
7	1	Setpoint Custom Control (32-bit value, LSW)	Unit	Setpoint custom control (unit depends on controlled peripheral)
8		Setpoint Custom Control (32-bit value, MSW)		
9	-	-	-	
10	-	-	-	
11	-	-	-	
12	1	Dosing state request	-	0.. Stop dosing 1.. Start dosing
13	0.1	Dosing volume (32-bit value, LSW)	mL	Dosing volume in mL
14		Dosing volume (32-bit value, MSW)		
15	1	Zero Adjustment Request	-	1.. Flow Zero Adjustment 2.. Pressure 1 Zero Adjustment 3.. Pressure 2 Zero Adjustment 4.. Pressure AnIn Zero Adjustment 5.. Custom AnIn Zero Adjustment 6.. Pressure 3 Zero Adjustment 7.. Flow RS485 Zero Adjustment
16	1	Recipe State Request	-	0.. Stop running recipe 1.. Start recipe 1 2.. Start recipe 2 3.. Start recipe 3 4.. Start recipe 4 5.. Start recipe 5 6.. Start recipe 6 7.. Start recipe 7 8.. Start recipe 8 9.. Start recipe 9 10.. Start recipe 10 11.. Start recipe 11 12.. Start recipe 12 13.. Start recipe 13 14.. Start recipe 14 15.. Start recipe 15 16.. Start recipe 16 17.. Start recipe 17 18.. Start recipe 18 19.. Start recipe 19 20.. Start recipe 20
17	1	Pressure Source for Pressure Control	-	0.. Pressure 1 1.. Pressure 2 2.. Pressure AnIn 3.. TM Pressure 4.. Pressure 3 5.. Delta P

18	1	Enable Volume counter for Flowmeter		0.. Disable 1.. Enable
19	1	Reset Volume counter for Flowmeter		1.. Reset
20	1	Increase Setpoint Speed	rpm	Increase actual setpoint speed by sent value
21	1	Decrease Setpoint Speed	rpm	Decrease actual setpoint speed by sent value
22	1	Increase Setpoint Flow	mlpm	Increase actual setpoint flow by sent value
23	1	Decrease Setpoint Flow	mlpm	Decrease actual setpoint flow by sent value
24	1	Increase Setpoint Pressure	mbar	Increase actual setpoint pressure by sent value
25	1	Decrease Setpoint Pressure	mbar	Decrease actual setpoint pressure by sent value
26	1	Flow Source for Flow Control		0.. Flowmeter 1.. Flow RS485
27	-	-	-	
28	-	-	-	
29	-	-	-	
30	-	-	-	
31	-	-	-	
32	-	-	-	
33	-	-	-	
34	-	-	-	
35	1	Acknowledge alert		1.. Acknowledges full-screen alert and resets pump if necessary
36	1	Custom Control Source		0.. Flowmeter 1.. Flow RS485 2.. Pressure 1 3.. Pressure 2 4.. Pressure 3 5.. TM Pressure 6.. Delta P 7.. Temperature 8.. Pressure AnIn 9.. Custom AnIn
37	1	Enable volume counter for Flow RS485		0.. Disable 1.. Enable
38	1	Reset Volume counter for Flow RS485		1.. Reset
39	1	Increase Setpoint PLC AnOut	Unit	Increase actual setpoint PLC AnOut by sent value
40	1	Decrease Setpoint PLC AnOut	Unit	Decrease actual setpoint PLC AnOut by sent value
41	1	Increase Setpoint Custom Control	Unit	Increase actual setpoint Custom Control by sent value
42	1	Decrease Setpoint Custom Control	Unit	Decrease actual setpoint Custom Control by sent value
43	1	Turn on/off digital output 1		0.. OFF 1.. ON PLC digital output 1 control needs to be activated in the settings
44	1	Turn on/off digital output 2		0.. OFF 1.. ON PLC digital output 2 control needs to be activated in the settings
45	1	Dosing Flow (32-bit value, LSW)	mlpm	Dosing flow in mlpm
46	1	Dosing Flow (32-bit value, MSW)		

Each hold register addresses a 16 bit (short) value.

3.2 Example: Read Hold register (MODBUS function 0x03)

In this example Hold register 1 is read.

→ Start Register 1 and Quantity of Registers = 1

MODBUS Request:

Function Code	Start Register		Quantity of Registers	
	MSB	LSB	MSB	LSB
0x03	**0x00**	**0x01**	**0x00**	**0x01**

MODBUS Response:

Function Code	Byte Count (Nr. Of value bytes)	Register #1 Value	
		MSB	LSB
0x03	**0x02**	**0x23**	**0x28**

→ Hold register 1: Setpoint speed 0x2328h = 9000 ≡ 9000 rpm

MODBUS Error Response:

Function Code	Exception Code
0x83	

Exception Code: 02 Invalid Start Register

03 Invalid combination (Start Register + Quantity of Registers)

3.3 Example: Write Single Hold register (MODBUS function 0x06)

In this example Hold register 1 is written.

→ Write value 2000 into Hold register 1

MODBUS Request:

Function Code	Register		Register Value	
	MSB	LSB	MSB	LSB
0x06	**0x00**	**0x01**	**0x07**	**0xD0**

MODBUS Response:

Function Code	Register		Register Value	
	MSB	LSB	MSB	LSB
0x06	**0x00**	**0x01**	**0x07**	**0xD0**

→ Wrote value 2000 to Hold register 1: Setpoint speed 0x07D0h = 2000 ≡ 2000 rpm

MODBUS Error Response:

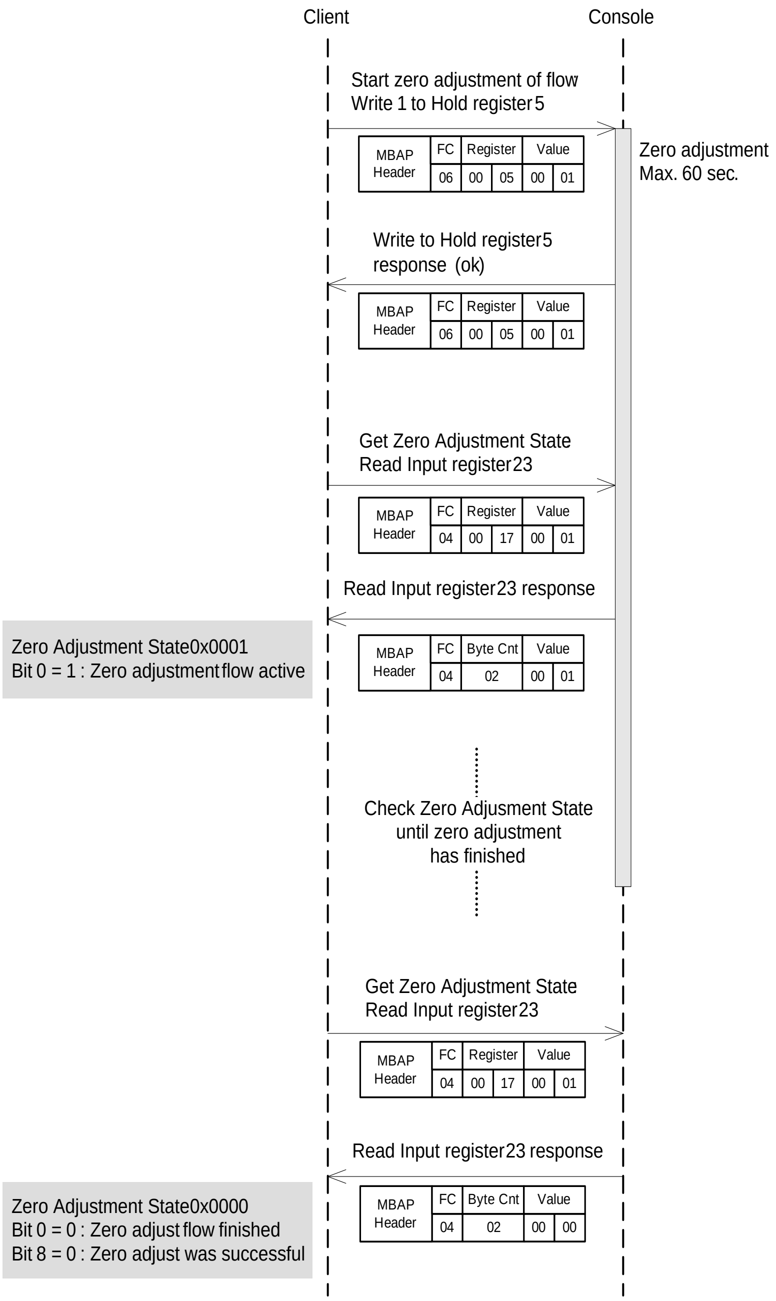
Function Code	Exception Code
0x86	

Exception Code:	
	02 Invalid Start Register
	03 Invalid combination (Start Register + Quantity of Registers)
	04 Impossible to execute, value not within allowed data range

4 Communication procedures

This chapter describes the most important communication procedures.

4.1 Zero adjustment



For a successful Zero flow adjustment, make sure that sensor is completely filled with liquid.

Trigger zero adjustment by setting 'zero adjustment flow bit' of 'zero adjustment request' register.

Then check zero adjustment state until Bit 0 turns to 0, which means the adjustment procedure has finished.

Bit 8 of zero adjustment state contains the result of the zero adjustment.

5 REVISION HISTORY

Rev.	DCO No.	DCO Author	Effectivity Date	Summary Description of Changes
00	18-037	P. Zingg	08-03-2018	First Release
01	18-128	P. Zingg	03-09-2018	Additional handles, new states added, up to 20 recipes with max. 10 phases available
02	19-043	P. Zingg	05-03-2019	Additional handles due to new console hardware
03	19-248	P. Zingg	13-12-2019	Additional handles, custom control support, diff pressure available, acknowledge alerts
04	21-299	P. Zingg	15-12-2021	Additional handles added, new flow RS458 sensortypes added