BlueEye™ Ex-D

Modbus
Communication
Protocol

MANUAL

BlueEye™ Ex-D Modbus Communication

The BlueEye™ Ex-D features RS485 Modbus communication, allowing the user to read measurement values, and configure the device according to individual preferences.

BlueEye™ Ex-D Modbus Communication - RS485 settings

Serial type	RS485
Bits per second	19200
Data bits	8
Parity	None
Stop bits	1
Flow control	None
Byte order	Little-endian

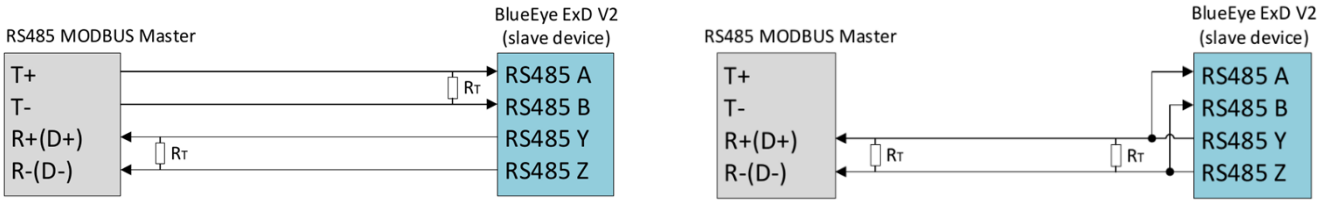
BlueEye™ Ex-D Modbus Communication – Wiring

Connect to the BlueEye™ Ex-D using either the full-duplex or the half-duplex RS485 Modbus configuration, as described in the wiring schematics below.
Once connected, the device can be accessed via its default Modbus address:
18 (0x12 in hexadecimal format).

BlueEye™ Ex-D Wiring

Wire ID	Description	
1, Black	Power supply	+24 VDC
2, Black	Power supply	-24 VDC
3, Black	4-20 mA Current Loop	+
4, Black	4-20 mA Current Loop	-
5, Black	T+	RS485_A
6, Black	T-	RS485_B
7, Black	R+ (D+)	RS485_Y
8, Black	R- (D-)	RS485_Z
9, Yellow/Green	GND	Ground

BlueEye™ Ex-D Modbus Wiring Schematics



BlueEye™ Ex-D Modbus Communication – Holding register

The device can be configured by modifying the holding register.

Changes to the holding register will only take effect if a valid configuration password has been entered in register 100, 101 and 102. This password protection is used to restrict modifications to the holding register (device settings), and it is recommended to set these register values to zero during normal operation.

There are six authorization level passwords which determine which settings the user can modify. These six levels are colour coded in the holding register table below.

Example: The user enters the level 1 password in registers 100, 101 and 102, and is then allowed to modify settings in registers 0 – 16, 34 – 38, 100, and 106 – 111. The remaining registers require a higher level of authorization and cannot be modified with a level 1 password.

BlueEye™ Ex-D Modbus Holding Register

Address (+40'001)	Type	Content	Options	Level					
				0	1	2	3	4	5
0	Int16	Unit settings	1: Metric1, 2: Metric2, 3: Imperial1, 4: Imperial2 See Unit Options table below	-	v	v	v	v	v
1	Int16	Reference conditions	1: 0°C/0°C, 2: 15°C/0°C, 3: 25°C/0°C, 4: 15°C/15°C, 5: 20°C/20°C, 6: 25°C/20°C at 1013.25 mbara. 7: 60°F at 14.696 psia, 8: 60°F at 14.65 psia, 9: 60°F at 14.73 psia, 10: 60°F at 15.025 psia.	-	v	v	v	v	v
2	Int16	Modbus moving average on/off	0: Off, 1: On, 2: Hourly average*	-	v	v	v	v	v
3	Int16	Modbus moving average count	Max. 10000	-	v	v	v	v	v
4	Int16	4-20 mA moving average	0: Off, 1: On, 2: Hourly average*	-	v	v	v	v	v
5	Int16	4-20 mA moving average count	Max. 10000.	-	v	v	v	v	v
…				-	v	v	v	v	v
10	Int16	Year	YYYY	-	v	v	v	v	v
11	Int16	Month	MM	-	v	v	v	v	v
12	Int16	Day	DD	-	v	v	v	v	v
13	Int16	Hour	hh	-	v	v	v	v	v
14	Int16	Minute	mm	-	v	v	v	v	v
15	Int16	Second	ss	-	v	v	v	v	v
16	Int16	Boosting	Write a '1' to initiate boosting (~5 minutes)	-	v	v	v	v	v
…									
18	Int16	Correlative model	0: Standard, 6: Hydrogen, 7: CO2	-	-	v	v	v	v

…									
30	Int16	Current loop DAC min	DAC value corresponding to 4mA	-	-	v	v	v	v
31	Int16	Current loop DAC max	DAC value corresponding to 20mA	-	-	v	v	v	v
32	Int16	Override DAC output	0: Normal current loop operation, 1: Override DAC output of the current loop	-	-	v	v	v	v
33	Int16	DAC value	DAC output (0-4096)	-	-	v	v	v	v
34	Int16	4-20 mA output parameter	1: WI_s, 2: H_s, 3: H_i, 4: Rho, 5: Rho rel., 6: Z, 7: AFR, 8: s-AFR, 9: MN, 10: WI_i, 11: CO_2, 12: H_2, 13: Temperature, 14: Absolute pressure	-	v	v	v	v	v
35	Float32	4 mA equivalent	Override default value	-	v	v	v	v	v
36									
37	Float32	20 mA equivalent	Override default value	-	v	v	v	v	v
38									
39	Float32	Granularity of average	For input registers: 110 - 137		v	v	v	v	v
40									
41	Int16	Zero CO2 sensor	Enter passcode 1200 to zero CO2 sensor	-	-	-	-	v	v
…									
49	Int16	Modbus address (1-255)	Set Modbus address. Default is 0x12. Restart device for change to take effect.	-	-	-	v	v	v
…									
100	Int16	Configuration password 1	Enter configuration password to change device settings. NOTE: The password might change depending on the setting the user wants to modify.	-	v	v	v	v	v
101	Int16	Configuration password 2							
102	Int16	Configuration password 3							
103	Int16	Viscosity & thermal conductivity passcode	Enter passcode to output parameters.	-	-	-	-	v	v
104	Int16	Normalized viscosity & thermal conductivity passcode	Enter passcode to output parameters.	-	-	-	-	v	v
105	Int16	Raw viscosity passcode	Enter passcode to output parameter.	-	-	-	-	v	v
106	Int16	GUI password 1	Enter GUI password to access the BlueEye Ex-D RS485 Interface. (Only relevant for customers that acquire said Interface)	v	v	v	v	v	v
107	Int16	GUI password 2							
108	Int16	GUI password 3							
109	Int16	Modbus password 1	Enter Modbus password to access the BlueEye Ex-D RS485 Interface with a certain authorization level. (Only relevant for customers that acquire said Interface)	v	v	v	v	v	v
110	Int16	Modbus password 2							
111	Int16	Modbus password 3							
112	Int16	Firmware upgrade password	Reserved for firmware upgrade password.	-	-	-	-	-	v
* Hourly average --> 1 data point per hour (ex: at 11h08 it shows average value for 10h00 to 11h00)									

Password entry:

When entering a password in registers 100 – 102, 106 – 108 or 109 – 111, the original password must be split in three parts before it can be saved to said registers. Below is an example of how a 6-character password is converted into three 16-bit values that can be saved to the registers.

Example: Save a 6-character configuration password to registers 100, 101, and 102.

```
password = 'KZbVe4'

password_utf8 = password.encode('utf-8')  # Encode password as UTF-8.

register100 = ((password_utf8[1] & 0xFF) << 8) | (password_utf8[0] & 0xFF)
```

register101 = ((password_utf8[3] & 0xFF) << 8) | (password_utf8[2] & 0xFF)

register102 = ((password_utf8[5] & 0xFF) << 8) | (password_utf8[4] & 0xFF)

Save the register100, register101 and register102 values to the holding registers 100, 101 and 102, respectively.

Unit Options Table

Unit Options	Energy	Pressure	Density	Temperature
Metric1	MJ/m³	Pa	kg/m³	°C
Metric2	KWh/m³	Pa	kg/m³	°C
Imperial1	Btu(IT)/scf	Psi	lb/scf	°F
Imperial2	therm(U.S)/scf	Psi	lb/scf	°F

BlueEye™ Ex-D Modbus Communication – Input register

The measurement output can be read from the input register. The user has read-only access to the input register. The output is updated every second.

Float32 data in the input register span 2 registers, as each register is 16bits wide. Consequently, a Float32 value must be calculated based on its two registers.

Here is an example of the "word swap" procedure to calculate the WI (Float32) based on register 0 and 1:

a. Read input register addr. 0 (lower addr.) → return 0x7e5d
b. Read input register addr. 1 (upper addr.) → return 0x4248
c. Concatenate the two values: 0x42487e5d
d. When interpreting this 32bits value as a Float32 (IEEE754) = 50.1234

The input register is described in the below table.

BlueEye™ Ex-D Modbus Input Register

Address (+30'001)	Type	Content	Details
0	Float32	WI_s	Unit and moving average settings: See holding register
1			
2	Float32	H_s	Unit and moving average settings: See holding register
3			
4	Float32	H_i	Unit and moving average settings: See holding register
5			
6	Float32	Rho	Unit settings: See holding register
7			
8	Float32	Rho relative	Unit settings: See holding register
9			
10	Float32	Temperature	Unit settings: See holding register
11			
12	Float32	Absolute pressure	Unit settings: See holding register

13			
14	Float32	CO_2 content	% mol
15			
16	Float32	H_2 content	% mol
17			
18	Float32	WI_i	Unit and moving average settings: See holding register
19			
20	Int16	Unit settings (1-4)	Unit settings: See holding register
21	Float32	Reference condition t_1	°C / °F, example: '15' or '60'
22			
23	Float32	Reference condition t_2	°C / psia, example: '0' or '14.696'
24			
25	Int16	Modbus moving average	0: Off, 1: On, 2: Hourly average
26	Int16	Modbus moving average count	Moving average over n measurements
27	Int16	4-20 mA moving average	0: Off, 1: On, 2: Hourly average
28	Int16	4-20 mA moving average count	Moving average over n measurements
…			
30	Float32	Z	
31			
32	Float32	AFR	
33			
34	Float32	s-AFR	
35			
36	Float32	MN	
37			
38	Int16	Viscosity sensor ID	
…			
40	Int16	Thermal Conductivity sensor ID1 (byte 0-1)	
41	Int16	Thermal Conductivity sensor ID2 (byte 2-3)	
42	Int16	Thermal Conductivity sensor ID3 (byte 4-5)	
43	Int16	Thermal Conductivity sensor ID4 (byte 6-7)	
44	Int16	Thermal Conductivity sensor ID5 (byte 8-9)	
45	Int16	Thermal Conductivity sensor ID6 (byte 10-11)	
46	Int16	Status1	See "Status1 register " table
47	Int16	Status2	See "Status2 register " table
48	Int16	Year	Current time of the system
49	Int16	Month	Current time of the system
50	Int16	Day	Current time of the system
51	Int16	Hour	Current time of the system
52	Int16	Minute	Current time of the system
53	Int16	Second	Current time of the system
54	Float32	Average granularity	For input registers: 110 - 137
55			
…			
60	Float32	20 mA equivalent	Currently used value
61			
62	Float32	4 mA equivalent	Currently used value

63			
64	Int16	4 mA calibration counter	Currently used value
65	Int16	20 mA calibration counter	Currently used value
66	Int16	4-20 mA output parameter	1: WI_s, 2: H_s, 3: H_i, 4: Rho, 5: Rho rel., 6: Z, 7: AFR, 8: s-AFR, 9: MN, 10: WI_i, 11: CO_2, 12: H_2, 13: Temperature, 14: Absolute pressure
67	Int16	Currently selected correlative model	0: Standard, 6: Hydrogen, 7: CO2
68	Int16	Firmware version	Example: 207 -> Version 2.0.7
…			
70	Int16	Interface login result	
71	Int16	Modbus address of device	
72	Int16	Available correlative models	Models: Extended, H2, CO2 Example: 101 -> Available models: Extended and CO2
73	Int16	Device hardware model	
74	Float32	Device serial ID	
75			
…			
84	Float32	Time constant	
85			
86	Float32	TCD transfer	
87			
88	Float32	Viscosity	
89			
90	Float32	Thermal conductivity	
91			
92	Float32	Raw viscosity	
93			
…			
96	Float32	Normalized viscosity	
97			
98	Float32	Normalized thermal conductivity	
99			
…			
110	Float32	Average WI_s	
111			
112	Float32	Average WI_i	
113			
114	Float32	Average H_s	
115			
116	Float32	Average H_i	
117			
118	Float32	Average Rho	
119			
120	Float32	Average Relative Rho	
121			

122	Float32	Average Z	
123			
124	Float32	Average AFR	
125			
126	Float32	Average s-AFR	
127			
128	Float32	Average MN	
129			
130	Float32	Average temperature	
131			
132	Float32	Average pressure	
133			
134	Float32	Average CO_2	
135			
136	Float32	Average H_2	
137			

BlueEye™ Ex-D Modbus Communication – Status registers

The status registers provide the user with information concerning the overall device status. When the device is working correctly the registers should display nominal values.

See below tables for a detailed overview of the status registers.

BlueEye™ Ex-D Modbus Status1 Register

Address (30'047)	Description	Details*
bit 0	WI_s and WI_i	0 = nominal / 1 = faulty
bit 1	H_s	0 = nominal / 1 = faulty
bit 2	H_i	0 = nominal / 1 = faulty
bit 3	Rho	0 = nominal / 1 = faulty
bit 4	Rho relative	0 = nominal / 1 = faulty
bit 5	Temperature	0 = nominal / 1 = faulty
bit 6	Absolute pressure	0 = nominal / 1 = faulty
bit 7	Viscosity	0 = nominal / 1 = faulty
bit 8	Thermal conductivity	0 = nominal / 1 = faulty
bit 9	Z	0 = nominal / 1 = faulty
bit 10	AFR	0 = nominal / 1 = faulty
bit 11	s-AFR	0 = nominal / 1 = faulty
bit 12	MN	0 = nominal / 1 = faulty
bit 13	Raw viscosity	0 = nominal / 1 = faulty
bit 14	Time and date have been set	0 = nominal / 1 = faulty
bit 15	Boosting	0 = nominal / 1 = sensor is boosting
*All 0 → Normal operation		

BlueEye™ Ex-D Modbus Status2 Register

Address (30'048)	Description	Details*
bit 0	SD card detected and functional	0 = nominal / 1 = faulty
bit 1	Viscosity sensor ID & alpha table ID match	0 = nominal / 1 = faulty
bit 2	SHT serial ID & alpha table serial ID match	0 = nominal / 1 = faulty
bit 3	TCD sensor ID & TC alpha poly ID match	0 = nominal / 1 = faulty
bit 4	4-20 mA calibration overridden	0 = nominal / 1 = faulty
bit 5	-	0 = nominal / 1 = faulty
bit 6	TC sensor	0 = nominal / 1 = faulty
bit 7	CO_2 sensor	0 = nominal / 1 = faulty
bit 8	-	0 = nominal / 1 = faulty
bit 9	-	0 = nominal / 1 = faulty
bit 10	-	0 = nominal / 1 = faulty
bit 11	-	0 = nominal / 1 = faulty
bit 12	-	0 = nominal / 1 = faulty
bit 13	-	0 = nominal / 1 = faulty
bit 14	-	0 = nominal / 1 = faulty
bit 15	-	0 = nominal / 1 = faulty
*All 0 → Normal operation		