Air Quality Systems

Stox Smart Gas Sensor Device
Modbus-RTU
User Communication Protocol

Easy Gas Sensor Device Solutions
Easy To Use

1. Product Overview and Configuration

1.1 Overview

The Stox has an RS485 Modbus-RTU output and the power supply is 12-24V DC, which is mainly used for continuous monitoring of the gas concentration. By instructing the protocol through the master and slave mode, the slave Stox only responds to the command sent by the master.

The Stox Smart Gas Sensor Device and PC, PLC or other devices can be realized for effective data transmission. The serial interface is an asynchronous half-duplex communication.

1.2 Configuration Parameters

<Table 1>

Baud rate	Data bit	Stop bit	Factory default address	Data reading and write time interval requirements	Check
9600	8 bit	1 bit	01 (0x01)	>=1s	Modbus-CRC16

2. Gas Concentration Unit

The concentration unit type of the product can be identified by reading the measured gas concentration unit value in the holding register. Most gas concentration units are ppm, Oxygen(O_2) is % vol. a few gases in the lower ranges use ppb.

<Table 2>

Value (Hex)	0x02	0x04	0x08
Gas Concentration Unit	ppm	ppb	%

3. Gas Sensor Type

Each gas sensor device has its own sensor type code, which can be identified by reading the gas sensor type code from the holding register. To read out the gas type code from the holding register, see the list of gas types with the corresponding code below.

<Table 3>

Sensor Type	HCHO	VOC	CO	Cl_2	H_2	H_2S	HCl	HCN	HF	NH_3	NO_2	O_2	O_3	SO_2
Value (Hex)	0x17	0x18	0x19	0x1A	0x1B	0x1C	0x1D	0x1E	0x1F	0x20	0x21	0x22	0x23	0x24

Sensor Type	HBr	Br_2	F_2	PH_3	AsH_3	SiH_4	GeH_4	B_2H_6	BF_3	WF_6	SiF_4	XeF_2	TiF_4	SMELL
Value (Hex)	0x25	0x26	0x27	0x28	0x29	0x2A	0x2B	0x2C	0x2D	0x2E	0x2F	0x30	0x31	0x32

Sensor Type	IAQ	AQI	NMHC	SO_x	NO_x	NO	C_4H_8	$C_3H_8O_2$	CH_4S	C_8H_8	C_4H_{10}	C_2H_6	C_6H_{14}	C_2H_4O
Value (Hex)	0x33	0x34	0x35	0x36	0x37	0x38	0x39	0x3A	0x3B	0x3C	0x3D	0x3E	0x3F	0x40

Sensor Type	C_3H_9N	C_2H_7N	C_2H_6O	CS_2	C_2H_6S	$C_2H_6S_2$	C_2H_4	CH_3OH	C_6H_6	C_8H_{10}	C_7H_8	CH_3COOH	ClO_2
Value (Hex)	0x41	0x42	0x43	0x44	0x45	0x46	0x47	0x48	0x49	0x4A	0x4B	0x4C	0x4D

Sensor Type	H_2O_2	N_2H_4	$C_2H_8N_2$	C_2HCl_3	$CHCl_3$	$C_2H_3Cl_3$	H_2Se	LEL	CO_2	PID_VOCS
Value (Hex)	0x4E	0x4F	0x50	0x51	0x52	0x53	0x54	0x55	0x56	0x57

4. ModBus-RTU Holding Register(03)

4.1 Modify the Modbus-RTU Address

The addresses of individual products need to be modified one by one, the addresses of multiple products cannot be modified at the same time.

The protocol default address is 0x01 when it is supplied by the manufacturer. The address can be modified according to the application. The address can be changed through 1(0x01)<=addr<=127(0x7F).

Command:

Command header										Address
0x80	0x72	0x65	0x70	0x6F	0x6C	0x65	0x76	0x65	0x44	x

Return:

Command header										Address
0xFF	0x72	0x65	0x70	0x6F	0x6C	0x65	0x76	0x65	0x44	x

4.2 Readout Measurement Data

Holding register address of the module parameters and real-time data that are read out with this group code: Gas concentration, temperature, humidity, range, gas concentration unit, gas sensor type. The code is only possible for readouts.

<Table 4>

REG (Hex)	Description	Data Type (Big-Endian)	Read/Write
0x2000 0x2001	Gas concentration measurement value	float	Read
0x2002	Temperature with 2 decimals (value from inside Stox housing)	int16	Read
0x2003	Relative humidity with 2 decimals (value from inside Stox housing)	uint16	Read
0x2004	Maximum range	uint16	Read
0x2005	Gas concentration unit (see table 2 above) Note: same with reg: 0x2006	uint8	Read
	Gas sensor type (see table 3 above) Note: same with reg: 0x2007	uint8	Read
0x2006	Gas concentration unit (see table 2 above)	uint16	Read
0x2007	Gas sensor type (see table 3 above)	uint16	Read
0x2008	Sensor lifetime and performance: 0: Working 1: Sensor close to failure, prepare replacement 2: Sensor failure, replace with new sensor	uint16	Read

Example to readout sensor data:

Sent: 0x01 0x03 0x20 0x00 0x00 0x09 0x8E 0x0C

Received: 0x01 0x03 0x12 0x3D 0xF3 0x36 0xE3 0x0C 0x72 0x13 0xE1 0x00 0x64 0x02 0x1C 0x00 0x02 0x00 0x1C 0x00 0x00 0xB3 0x78

Sent explanation:

0x01----------Address

0x03----------Read code

0x20 0x00----------Start register

0x00 0x09----------Read reg length

0x8E 0x0C----------Modbus-RTU CRC

Received explanation:

0x01----------Address
0x03----------Read code
0x12----------Raed byte length - 18
0x3D 0xF3 0x36 0xE3----------Concentration - 0x3DF336E3 - 0.118757f (IEEE754 single precision 32-bit)
0x0C 0x72----------Temperature - 0x0C72 (2 decimal places) - 31.86℃
0x13 0xE1----------Relative humidity - 0x13E1 (2 decimal places) - 50.89% RH
0x00 0x64----------Maximum range - 0x0064 - 100
0x02 0x1C----------Gas concentration unit and gas sensor type - ppm and H_2S
0x00 0x02----------Gas concentration unit - ppm
0x00 0x1C----------Gas sensor type - H_2S
0x00 0x00---------- Sensor lifetime - normal operation
0xB3 0x78----------Modbus-RTU CRC

Reference information for float data conversion:

http://www.binaryconvert.com/convert_float.html?
When converted to C language use:

```
typedef union {
float data;
uint32_t uint32_data;
uint8_t uint8_data[4];
}FLOAT_DATA_U;
```

4.3 Gas Concentration Calibration Register (Modify 0 point calibration value)

Applicable to trace concentration calibration, the 0 point value is modified.

<Table 5>

REG (Hex)	Description	Data Type (Big-Endian)	Read/Write
0x3070 0x3071	Write calibration gas concentration value	float	Write

Example to write calibration concentration (0.03 (ppm/ppb/%)):

Sent: 0x01 0x10 0x30 0x70 0x00 0x02 0x04 0x3C 0xF5 0xC2 0x8F 0xAC 0x2C
Received: 0x01 0x10 0x30 0x70 0x00 0x02 0x4F 0x13

Sent explanation:

0x01----------Address
0x10----------Write code
0x30 0x70----------Start reg
0x00 0x02----------Write reg length
0x04----------Write byte length
0x3C 0xF5 0xC2 0x8F----------Write concentration - 0x3CF5C28F - 0.03f (IEEE754 Single precision 32-bit)
0xAC 0x2C----------Modbus-RTU CRC

Received explanation:

0x01----------Address
0x10----------Write code
0x30 0x70---------- Is written to the start register
0x00 0x02----------The length of the register being written.
0x4F 0x13----------Modbus-RTU CRC

4.4 Gas Concentration Calibration Register (Recommended target gas concentration > 10% FS)

Applicable to calibration when there is target gas and the target gas concentration is not less than 10 % of the range. The sensitivity value is modified.

<Table 6>

REG (Hex)	Description	Data Type (Big-Endian)	Read/Write
0x3080 0x3081	Write calibration gas concentration value (> 0)	float	Write

Example to write calibration concentration (10 (ppm/ppb/%)):

Sent: 0x01 0x10 0x30 0x80 0x00 0x02 0x04 0x41 0x20 0x00 0x00 0xBA 0x38
Received: 0x01 0x10 0x30 0x80 0x00 0x02 0x4F 0x20

Sent explanation:

0x01----------Address
0x10----------Write code
0x30 0x80----------Start reg
0x00 0x02----------Write reg length
0x04----------Write byte length
0x41 0x20 0x00 0x00----------Write concentration - 0x41200000 - 10.0f (IEEE754 Single precision 32-bit)
0xBA 0x38----------Modbus-RTU CRC

Received explanation:

0x01----------Address
0x10----------Write code
0x30 0x80---------- Is written to the start register
0x00 0x02----------The length of the register being written.
0x4F 0x20----------Modbus-RTU CRC

4.5 Reset Factory Calibration Data

<Table 7>

REG (Hex)	Description	Data Type (Big-Endian)	Read/Write
0x3010	Reset factory calibration data 1: Reset Other: No operation	uint16	Write

Example to reset factory calibration data:

Sent: 0x01 0x06 0x30 0x10 0x00 0x01 0x46 0xCF
Received: 0x01 0x06 0x30 0x10 0x00 0x01 0x46 0xCF

Example to reset factory calibration data:

Sent: 0x01 0x06 0x30 0x10 0x00 0x01 0x46 0xCF
Received: 0x01 0x06 0x30 0x10 0x00 0x01 0x46 0xCF

Sent explanation:

0x01----------Address
0x06----------Write code
0x30 0x10----------Write reg
0x00 0x01----------Reset factory calibration data
0x46 0xCF----------Modbus-RTU CRC

Received explanation:

0x01----------Address
0x06----------Write code
0x30 0x10----------Write reg
0x00 0x01----------Reset factory calibration data
0x46 0xCF----------Modbus-RTU CRC

4.6 Readout Firmware Version

<Table 8>

REG (Hex)	Description	Data Type (Big-Endian)	Read/Write
0x3020	Firmware version	HEX	Read
0x3021			
0x3022			

Note: It is related with the Stox Firmware Version 202310311540

Example to read firmware version:

Sent: 0x01 0x03 0x30 0x20 0x00 0x03 0x0B 0x01
Received: 0x01 0x03 0x06 0x20 0x23 0x09 0x20 0x12 0x41 0x2D 0x14

Sent explanation:

0x01----------Address
0x03----------Read code
0x30 0x20----------Start reg
0x00 0x03----------Read reg length
0x0B 0x01----------Modbus-RTU CRC

Received explanation:

0x01----------Address
0x03----------Read code
0x06----------Read byte length
0x20 0x23 0x09 0x20 0x12 0x41— 0x202309201241 - 202309201241(BCD)
0x2D 0x14----------Modbus-RTU CRC

4.7 Readout Sensor Serial Number

<Table 9>

REG (Hex)	Description	Data Type (Big-Endian)	Read/Write
0x3030	Sensor serial number	HEX	Read
0x3031			
0x3032			

Example to read serial number version:

Sent: 0x01 0x03 0x30 0x30 0x00 0x03 0x0A 0xC4
Received: 0x01 0x03 0x06 0x00 0x00 0x60 0x41 0x89 0x19 0xC9 0x3B

Sent explanation:

0x01----------Address
0x03----------Read code
0x30 0x30----------Start reg
0x00 0x03----------Read reg length
0x0A 0xC4----------Modbus-RTU CRC

Received explanation:

0x01----------Address
0x03----------Read code
0x06----------Read byte length
0x00 0x00 0x60 0x41 0x89 0x19 — 0x000060418919 - 000060418919 (BCD)
0xC9 0x3B----------Modbus-RTU CRC

4.8 4~20mA Current Calibration

<Table 10>

REG (Hex)	Description	Data Type (Big-Endian)	Read/Write
0x3040	Force output current 0: Turn off forced output current 1: Force output 4mA current 2: Force output 20mA current Others: no operation	uint16	Write
0x3041	When operating forced output of 4mA current, write the current value. (If the forcedoutput 0mA is switched off, writing is invalid)	float	Write
0x3042			
0x3043	When operating forced output of 20mA current, write the current value. (If the forced output 20mA is switched off, writing is invalid)	float	Write
0x3044			
0x3045	4~20mA output reset to factory data 1: Reset to factory data Others: No operation	uint16	Write

Example to calibrate the 4~20mA current:

Step 1--Force output 4mA current

Sent: 0x01 0x06 0x30 0x40 0x00 0x01 0x46 0xDE
Received: 0x01 0x06 0x30 0x40 0x00 0x01 0x46 0xDE

Example to calibrate the 4~20mA current:

Step 1--Force output 4mA current

Sent: 0x01 0x06 0x30 0x40 0x00 0x01 0x46 0xDE
Received: 0x01 0x06 0x30 0x40 0x00 0x01 0x46 0xDE

Sent explanation:

0x01----------Address
0x06----------Write code
0x30 0x40----------Write reg
0x00 0x01----------Force output 4mA
0x46 0xDE----------Modbus-RTU CRC

Received explanation:

0x01----------Address
0x06----------Write code
0x30 0x40----------Write reg
0x00 0x01----------Force output 4mA
0x46 0xDE----------Modbus-RTU CRC

Step 2--Read the current value from the ammeter. If the current value read is: 4.03mA

Step 3--Write the current value to the 0x3041 register

Sent: 0x01 0x10 0x30 0x41 0x00 0x02 0x04 0x40 0x80 0xF5 0xC2 0xB0 0xBB
Received: 0x01 0x10 0x30 0x41 0x00 0x02 0x1E 0xDC

Sent explanation:

0x01----------Address
0x10----------Write code
0x30 0x41----------Start reg
0x00 0x02----------Write reg length
0x04----------Write byte length
0x40 0x80 0xF5 0xC2----------Write current value - 0x4080F5C2 - 4.03f
0xB0 0xBB----------Modbus-RTU CRC

Received explanation:

0x01----------Address
0x10----------Write code
0x30 0x41----------Is written to the start register
0x00 0x02----------The length of the register being written
0x1E 0xDC----------Modbus-RTU CRC

Step 4-- Force output 20mA current

Sent: 0x01 0x06 0x30 0x40 0x00 0x02 0x06 0xDF
Received: 0x01 0x06 0x30 0x40 0x00 0x02 0x06 0xDF

Sent explanation:

0x01----------Address
0x06----------Write code
0x30 0x40----------Write reg
0x00 0x02----------Force output 20mA
0x06 0xDF----------Modbus-RTU CRC

Received explanation:

0x01----------Address
0x06----------Write code
0x30 0x40----------Write reg
0x00 0x02----------Force output 20mA
0x06 0xDF----------Modbus-RTU CRC

Step 5--Read the current value from the ammeter. If the current value read is: 20.03mA

Step 6--Write the current value to the 0x3043 register

Sent: 0x01 0x10 0x30 0x43 0x00 0x02 0x04 0x41 0xA0 0x3D 0x70 0xE6 0xE1

Received: 0x01 0x10 0x30 0x43 0x00 0x02 0xBF 0x1C

Sent explanation:

0x01----------Address
0x10----------Write code
0x30 0x43----------Start reg
0x00 0x02----------Write reg length
0x04----------Write byte length
0x41 0xA0 0x3D 0x70----------Write current value - 0x41A03D70 - 20.03f
0xE6 0xE1----------Modbus-RTU CRC

Received explanation:

0x01----------Address
0x10----------Write code
0x30 0x43----------Is written to the start register
0x00 0x02----------The length of the register being written
0xBF 0x1C----------Modbus-RTU CRC

Step 7--Switch off forced output current

Sent: 0x01 0x06 0x30 0x40 0x00 0x00 0x87 0x1E

Received: 0x01 0x06 0x30 0x40 0x00 0x00 0x87 0x1E

Sent explanation:

0x01----------Address
0x06----------Write code
0x30 0x40----------Write reg
0x00 0x00----------Switch off forced output current
0x87 0x1E----------Modbus-RTU CRC

Received explanation:

0x01----------Address
0x06----------Write code
0x30 0x40----------Write reg
0x00 0x02----------Switch off forced output current
0x87 0x1E----------Modbus-RTU CRC

Example to 4~20mA output reset to factory data:

Sent: 0x01 0x06 0x30 0x45 0x00 0x01 0x56 0xDF

Received: 0x01 0x06 0x30 0x45 0x00 0x01 0x56 0xDF

Sent explanation:

0x01----------Address
0x06----------Write code
0x30 0x45----------Write reg
0x00 0x01----------Reset to factory data
0x56 0xDF----------Modbus-RTU CRC

Received explanation:

0x01----------Address
0x06----------Write code
0x30 0x45----------Write reg
0x00 0x01----------Reset to factory data
0x56 0xDF----------Modbus-RTU CRC

4.9 Sensor Sensitivity Calibration (without gas)

If new sensor is inserted, the sensor sensitivity has dropped or you want to recalibrate the Stox with a different source gas, you can use the sensor sensitivity data provided from AQ Sense to perform the calibration without gas.

<Table 11>

REG (Hex)	Description	Data Type (Big-Endian)	Read/Write
0x3050 0x3051	Write sensor zero point current (nA)	float	Write
0x3052 0x3053	Write sensor sensitivity (>0nA)	float	Write

4.9.1 Zero Point Calibration

Example to write sensor zero point current (nA):

Sent: 0x01 0x10 0x30 0x50 0x00 0x02 0x04 0x41 0x20 0x00 0x00 0xB7 0x64
Received: 0x01 0x10 0x30 0x50 0x00 0x02 0x4E 0xD9

Sent explanation:
0x01----------Address
0x10----------Write code
0x30 0x50----------Start reg
0x00 0x02----------Write reg length
0x04----------Write byte length
0x41 0x20 0x00 0x00---------- Write sensor zero point current - 0x41200000 - 10nA
0xB7 0x64----------Modbus-RTU CRC

Received explanation:
0x01----------Address
0x10----------Write code
0x30 0x50----------Is written to the start register
0x00 0x02----------The length of the register being written.
0x4E 0xD9----------Modbus-RTU CRC

4.9.2 Span Calibration

Example write sensor sensitivity (>0nA)

Sent: 0x01 0x10 0x30 0x52 0x00 0x02 0x04 0x41 0xF0 0x00 0x00 0x37 0x44
Received: 0x01 0x10 0x30 0x52 0x00 0x02 0xEF 0x19

Sent explanation:
0x01----------Address
0x10----------Write code
0x30 0x52----------Start reg
0x00 0x02----------Write reg length
0x04----------Write byte length
0x41 0xF0 0x00 0x00---------- Write sensor sensitivity - 0x41F00000 - 30nA
0x37 0x44----------Modbus-RTU CRC

Received explanation:
0x01----------Address
0x10----------Write code
0x30 0x52----------Is written to the start register
0x00 0x02----------The length of the register being written.
0xEF 0x19----------Modbus-RTU CRC

4.10 Readout Measurement Data(without negative suppression)

If the sensor displays a negative value under various conditions, it is possible to use the command below to read the real-time data without negative suppression. Normally, the above "Table 4" with negative suppression cannot display a negative reading.
It is possible to use the negative value for further algorithms or judgments if necessary.

<Table 12>

REG (Hex)	Description	Data Type (Big-Endian)	Read/Write
0x3060 0x3061	Gas concentration measurement value (without negative suppression)	float	Read
0x3062	Temperature with 2 decimals (value from inside Stox housing)	int16	Read
0x3063	Relative humidity with 2 decimals (value from inside Stox housing)	Uint16	Read
0x3064	Maximum range	Uint16	Read
0x3065	Gas concentration unit	Uint8	Read
	Gas sensor type	Uint8	Read
0x3066	Gas concentration unit	Uint16	Read
0x3067	Sensor type	Uint16	Read
0x3068	Sensor lifetime and performance: 0: Working 1: Sensor close to failure, prepare replacement 2: Sensor failure, replace with new sensor	Uint16	Read

Example to read sensor data:

Sent: 0x01 0x03 0x30 0x60 0x00 0x09 0x8A 0xD2

Received: 0x01 0x03 0x12 0xBF 0x02 0xFC 0xF9 0x0C 0x2D 0x16 0x3D 0x00 0x0A 0x02 0x20 0x00 0x02 0x00 0x20 0x00 0x00 0xF5 0xDA

Sent explanation:

0x01----------Address
0x03----------Read code
0x30 0x60----------Start reg
0x00 0x09----------Read reg length
0x8A 0xD2----------Modbus-RTU CRC

Received explanation:

0x01----------Address
0x03----------Read code
0x12----------Raed byte length - 18
0xBF 0x02 0xFC 0xF9----------Concentration - 0xBF02FCF9 -- 0.511f (IEEE754 single precision 32-bit)
0x0C 0x2D----------Temperature - 0x0C2D (2 decimal places) - 31.17℃
0x16 0x3D----------Relative humidity - 0x163D (2 decimal places) - 56.93% RH
0x00 0x0A----------Maximum range - 0x000A - 10
0x02 0x20----------Unit and sensor type - ppm and NH_3
0x00 0x02----------Unit - ppm
0x00 0x20----------Sensor type - NH_3
0x00 0x00----------Sensor fault code - normal operation
0xF5 0xDA----------Modbus-RTU CRC

4.11 Device Name

<Table 13>

REG (Hex)	Description	Data Type (Big-Endian)	Read/Write
0xFF00	Device name: STOX	ascii	Read
0xFF01			
0xFF02			
0xFF03			
0xFF04			
0xFF05			
0xFF06			
0xFF07			

Example to read device name:

Sent: 0x01 0x03 0xFF 0x00 0x00 0x08 0x74 0x18

Received: 0x01 0x03 0x10 0x53 0x54 0x4F 0x58 0x2E 0x2E 0x2E 0x2E 0x2E 0x2E 0x2E 0x2E 0x2E 0x2E 0x2E 0x2E 0x48 0x01

Sent explanation:

0x01----------Address
0x03----------Read code
0xFF 0x00----------Start reg
0x00 0x08----------Read reg length
0x0B 0x01----------Modbus-RTU CRC

Received explanation:

0x01----------Address
0x03----------Read code
0x10----------Read byte length
0x53 0x54 0x4F 0x58 0x2E 0x2E 0x2E 0x2E 0x2E 0x2E 0x2E 0x2E 0x2E 0x2E 0x2E 0x2E---------Device name - STOX.....(ascii)
0x48 0x01----------Modbus-RTU CRC

Note: The conversion from float to 32 to integer data follows the IEEE754 single precision 32-bit standard, and all multi-byte data is in big-endian mode.

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