Digital Dissolved Oxygen Sensor

Basic User Manual

Model: OPD505A

Version 1.0

Introduction

Dear user

Thank you very much for using the salinity sensor of our company. Before you use it, please read this manual in detail, it will be of great help to the use and maintenance of this instrument, and can avoid unnecessary troubles due to improper operation and maintenance.

Please follow the operating procedures and precautions of this manual.

To ensure that the after-sales protection provided by this instrument is effective, please do not use and maintain this instrument by methods other than those specified in this manual.

Any failures and losses caused by non-compliance with the precautions specified in this manual are not covered by the manufacturer's warranty, and the manufacturer does not assume any related responsibilities. Please keep all documents in a safe place. If you have any questions, please contact our after-sales service department.

When receiving the instrument, please carefully open the package and check whether the instrument and accessories are damaged due to transportation. If any damage is found, please contact our after-sales service department and save the packaging for return processing.

When the instrument fails, please do not repair it by yourself, please contact our after-sales service department.

Warranty Description

This quality guarantee does not cover the following situations:

1. Damage caused by force majeure, natural disasters, social unrest, war (announced or unannounced), terrorism, civil war or any government coercion;
2. Damage caused by improper use, negligence, accident or improper application and installation;
3. Freight for returning the goods to our company;
4. Expedited or express freight for parts or products within the scope of warranty;
5. Travel expenses for local warranty repairs.

This quality assurance includes all the content of the quality assurance provided by its products. This quality assurance constitutes a final, complete and exclusive statement about the terms of the quality assurance. No one or agent is authorized to formulate other warranties in the name of our company.

The above-mentioned remedial measures such as repair, replacement or refund of the purchase price are special cases that do not violate this warranty, and the remedial measures such as replacement or refund of the purchase price are all for the company's product itself. Based on strict liability obligations or other legal theories, the company is not liable for any other damage caused by product defects or negligence in operation, including subsequent damages that have a causal relationship with these conditions.

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Chapter 1 Basic Information

1.1 Overview

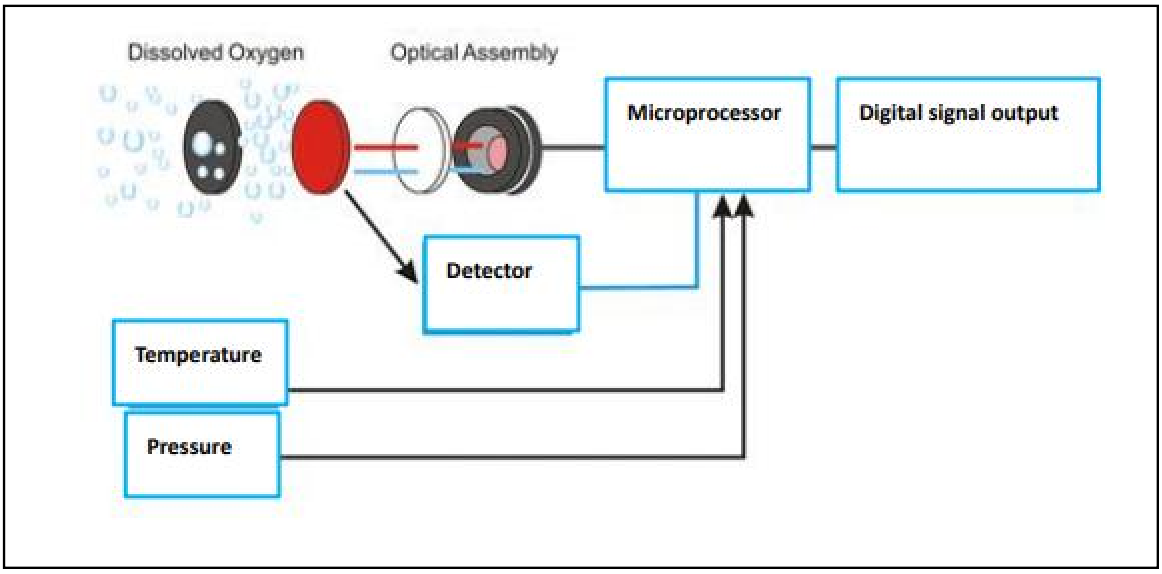
The dissolved oxygen sensor uses fluorescent principle. No oxygen consumption, no flow rate limitation, no electrolyte, no maintenance and calibration, strong anti-interference ability, and excellent stability. Built-in temperature sensor, automatic temperature compensation. RS485 output, can be networked without a controller.

1.2 Features

- Digital sensor, RS485 output, support MODBUS;
- No membrane, no electrolyte, no interference, no frequent calibration;
- No oxygen consumption, no flow rate limitation.

1.3 Principle

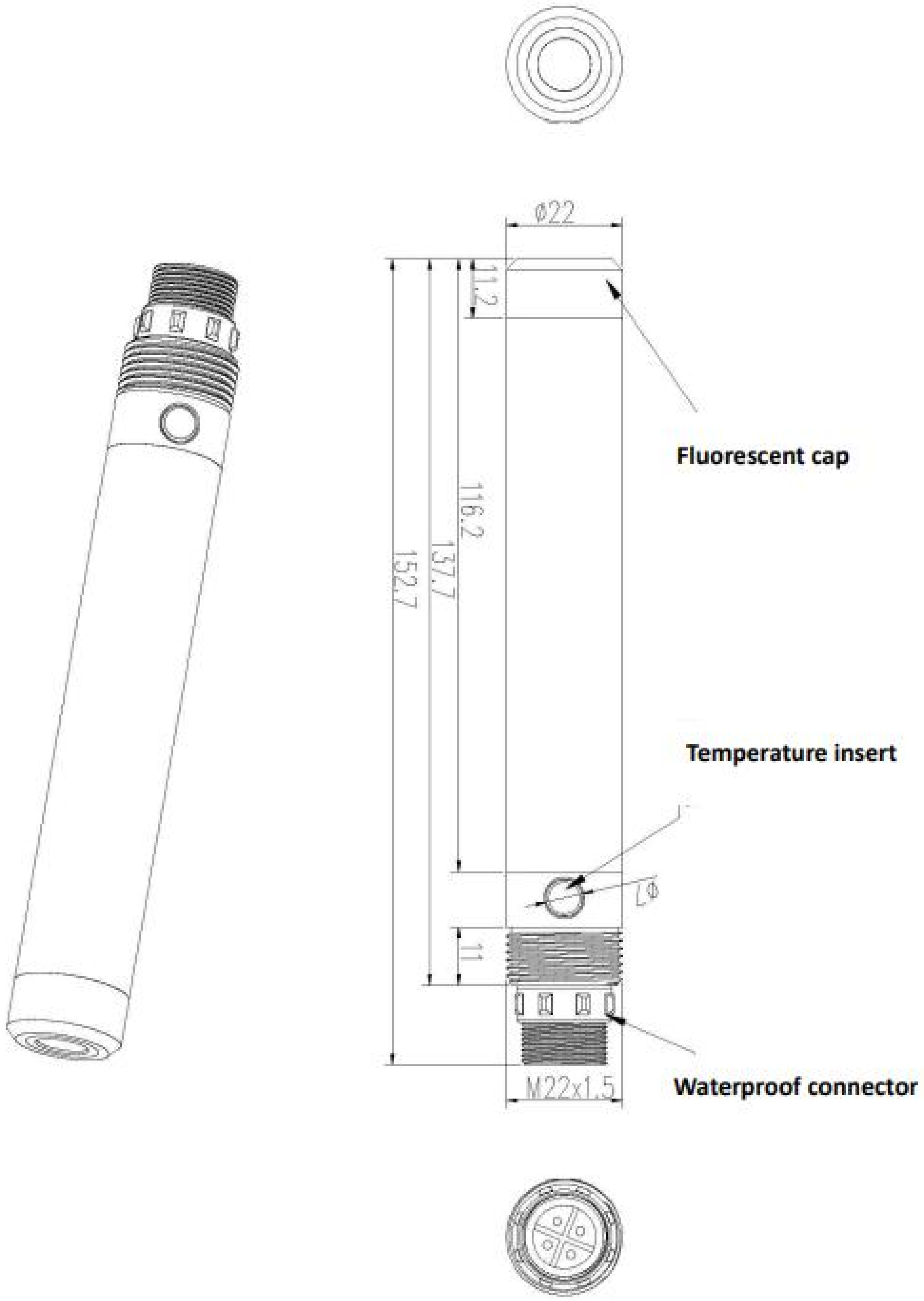
Fluorescence dissolved oxygen sensor is based on the quenching principle of active fluorescence by specific substances in physics. The blue light emitted from a light emitting diode (LED) irradiates the fluorescent material on the inner surface of the fluorescent cap. The fluorescent material on the inner surface is excited to emit red light. The phase difference between the red light and the blue light is detected and compared with the internal calibration value. Comparing to calculate the concentration of oxygen molecules, the final value is automatically compensated by temperature and air pressure.



Chapter 2 Specification

Measuring Principle	Fluorescence
DO Measuring Range	Dissolved oxygen concentration 0-20mg/L Saturation 0-200%
DO Measuring Accuracy	3%
Temp Accuracy	±0.5℃
Temp Sensor	NTC
Response Time	T_{90} less than 60s
Calibration Method	One or two points
Sensor Drift	<3% per year
Working Temp	0 to 50℃
Working Pressure	≤6bar
Sensor Interface	Support RS485 Modbus protocol
Installation	M22*1.5mm
Protection Grade	IP68
Power	DC 6~12V, current<50mA
Main Material	Ti, POM
Sensor Service Life	one year (under normal circumstances)
Shell Dimension	Φ22mm*L 188.3mm
Cable Length	Standard 10 meters, length can be customized

Chapter 3 Dimension



Chapter 4 Cable Definition

- Do sensor dimension

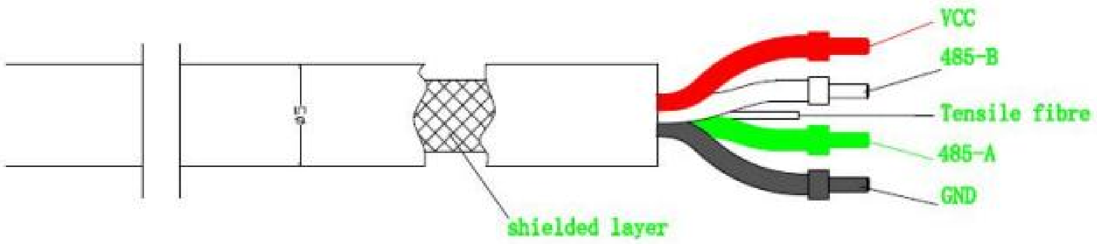
22*188.3mm (ΦX L)

- Power supply

The power supply must be DC 6~12V±5%. Current <50mA

- Cable information

4 wire AWG-24 or AWG-26 shielding wire. OD=5mm



1. Red wire — Power (VCC)
2. White wire — 485_B
3. Green wire — 485_A
4. Black wire — Ground wire (GND)
5. Bare wire — Shield

Chapter 5 Maintenance

5.1 Maintenance Cycle

Unlike electrochemical dissolved oxygen probe technology, fluorescent dissolved oxygen probes do not consume oxygen and do not require frequent cleaning (except when used in viscous liquids).

Maintenance task	Recommended maintenance frequency
Clean the sensor	Wash every 30 days
Check the sensor and fluorescent cap for damage	Check every 30 days
Replace the fluorescent cap	Replace once a year
Calibrate the sensor	According to the maintenance schedule required by the competent authority

Note:
The maintenance frequency in the above table is only a suggestion, please ask the maintenance personnel to clean the sensor according to the actual use of the sensor; however, the replacement of the fluorescent cap, we recommend that it be replaced once a year.

5.2 Maintenance Method

Sensor maintenance

1) The outer surface of the sensor: Clean the outer surface of the sensor with tap water. If there is still debris, wipe it with a damp soft cloth. For some stubborn dirt, you can add some household detergent to the tap water to clean;

2) The outer surface of the fluorescent cap: remove the protective cover at the front of the sensor, rinse the dirt on the light window of the sensor with clean water, and finally cover the cover; if you need to wipe, please use a soft cloth and be careful about the strength and direction of force; cause scratches, the sensor will not work properly;

3) The inner surface of the fluorescent cap: If water vapor or dust has penetrated into the fluorescent cap, the cleaning steps are as follows:

a. Remove the fluorescent cap

b. Rinse the inner surface of the fluorescent cap with tap water

c. For greasy and oily soils, wash with warm water with household detergent

d. Rinse the inner surface of the fluorescent cap with deionized water

e. Gently dry all surfaces with a clean, lint-free cloth and leave in a dry place to allow the moisture to completely evaporate

4) Check the cable of the sensor: the cable should not be taut during normal operation, otherwise it is easy to break the internal wire of the cable, causing the sensor to not work normally;
5) Check whether the housing of the sensor is damaged due to corrosion or other reasons.
6) Daily storage of fluorescent cap: When not in use, put it in a protective cover with a moist sponge to keep the sensor moist for a long time. If the sensor fluorescent cap is in a dry state for a long time, the measurement result will drift, and it needs to be soaked in water for 48 hours before continuing to work.

Note:
1) Avoid sun exposure on the inner surface of the fluorescent cap.
2) Please do not touch the fluorescent film with your hands.
3) Avoid applying any mechanical stress (pressure, scratches, etc.) directly to the fluorescent film during use.

Chapter 6 Frequently Asked Questions

Fault	Reasons	Solutions
The operation interface cannot be connected; Do not display the measurement results	Controller and cable connection error	Reconnect the controller and cables
	Cable failure	Please contact us
	The fluorescent cap is not tightened or is damaged	Reinstall and tighten the fluorescent cap or replace the fluorescent cap
The measured value is too high, too low or the value is continuously unstable	The outer surface of the fluorescent cap is attached by foreign objects	Clean the outer surface of the fluorescent cap and agitate the probe during measurement
	The fluorescent cap is damaged	Replace teh fluorescent cap
	The fluorescent cap has exceeded its service life	
The temperature measurement value exceeds the measurable range or the reading is garbled	Controller and cable connection error	Reconnect the controller and temperature sensor cables
	The temperature sensor is attached to a foreign object	Use a soft brush to gently brush away the attachments

Chapter 7 Sensor Calibration

The DO sensor is calibrated to specification at the factory. The manufacturer does not recommend calibration unless periodically required by regulatory agencies. If calibration is required, let the sensor come to equilibrium with the process before calibration. After the membrane cap is replaced, calibration should be carried out. It is also advisable to regularly clean the sensor.

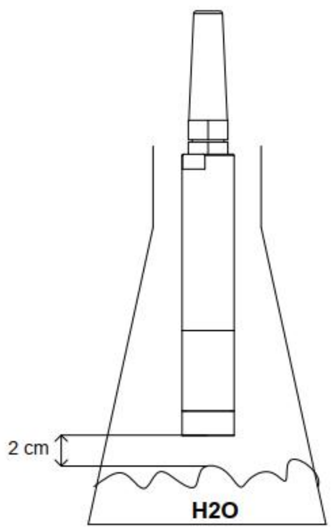
7.1 Calibration in 2 Point

With two-point calibration, the zero point (0% - offset) and slope (100 % - gain) of the sensor are calibrated. This calibration method offers the greatest possible level of accuracy and is particularly recommended for measurements of small oxygen concentrations.

It is carried out as follows:

- The sensor must first set the **gain** and the **offset** to 1.000 and 0.000.
- Then sensor gain is determined by positioning in oxygen-saturated environment (100 % saturation). This state can in principle be achieved in two ways:
  • By positioning the sensor in water vapor-saturated air (for example, directly over a water surface).
  • By positioning the sensor in air-saturated water (air is directed through water until the water is saturated with it).
  The illustration below is a representation of the conditions in water vapor-saturated air.
- Then wait for the sensor DO% reading to stabilize and record the DO% value as R_{100}.
- Then the sensor is immersed in a water-sulphite solution (sulphite concentration < 2 %) in order to determine the zero point (0 % saturation). Mix the solution with the sensor so that the saturation in oxygen decreases more quickly.
- Then wait for the sensor DO% reading to stabilize and record the DO% value as R_0.
- Then calculate the gain and offset according to the following formula.

  gain = (100 - 0) / (R_{100} - R_0), **offset** = -**gain** * R_0
- Finally write the **gain** and **offset** to the sensor to complete the calibration.



NOTE:
Damage to the sensor membrane due to chemicals.
A damaged membrane can lead to incorrect measurement results. The sensor membrane must not be in contact with the sulphite solution for longer than one hour.
After calibration, the sulfite solution on the sensor must be thoroughly cleaned before it can be used.

7.2 Calibration in 1 Point

The calibration in 1 point only 100% gain is calibrated, which is easy to achieve in most applications.

It is carried out as follows:

- The sensor must first set the **gain** and the **offset** to 1.000 and 0.000.
- Then put the sensor in oxygen-saturated environment (100 % saturation), and wait for the sensor DO% reading to stabilize and record the DO% value as R_{100}.
- Then calculate the gain according to the following formula.

$$\textbf{gain} = 100 / R_{100}$$

- Finally, the calculated gain and offset values of 0.000 are written to the sensor to complete the calibration..

NOTE: The DO sensor need to be thoroughly cleaned before calibration.

Chapter 8 DO Sensor Commands in MODBUS RTU

8.1 Overview

For MODBUS RTU communication with the optical DO sensor electrodes, the MODBUS master terminal application software is required. MODBUS RTU is an open standard that provides several free commercial application toolkits.
In this manual, the addresses of the MODBUS registers start from 1. However, the MODBUS master protocol works from register address 0. Usually, the MODBUS master software compiles the address. Therefore, register address 2090 will be compiled to 2089 by the MODBUS master software.

8.2 Details of Each Command

8.2.1 Set Slave ID

Function: Set the MODBUS slave device address of the sensor, the address range is 1~247. The MODBUS slave device address of the sensor can be set through the MODBUS register with address 0x3000.

Start register	Register quantity	Register1	MODBUS Function Code
0x3000	0x01	New device address	0x10

Set Slave ID Command Register Definition

Take the sensor's old device address = 0x01 and new device address = 0x14 as an example to illustrate the request frame and response frame for setting the slave ID command.

Definition	Address domain	Function code	Initial address		Register quantity		Byte count	Register value		CRC	
Byte	0	1	2	3	4	5	6	7	8	9	10
Content	0x01	0x10	0x30	0x00	0x00	0x01	0x02	0x14	0x00	0x99	0x53

Example of setting slave ID request frame

Remarks: byte8 is a reserved value, meaningless

Definition	Address Domain	Function code	Initial address		Register quantity		CRC	
Byte	0	1	2	3	4	5	6	7
Content	0x01	0x10	0x30	0x00	0x00	0x01	0x0E	0xC9

Example of setting slave ID response frame

8.2.2 Get SN

Function: Get the identification number SN of the sensor, each sensor has a unique SN. The SN of the probe can be read from 7 consecutive MODBUS registers starting at 0x0900.

Start register	Register quantity	Register1-7	MODBUS Function Code
0x0900	0x07	SN	0x03

Get SN Command Register Definition

The following takes the slave device address 0x01 and the returned SN " YL0114010022" as an example to illustrate the request frame and response frame for obtaining the SN command.

Definition	Address domain	Function code	Initial address		Register quantity		CRC	
Byte	0	1	2	3	4	5	6	7
Content	0x01	0x03	0x09	0x00	0x00	0x07	0x07	0x94

Example of getting SN command request frame

Definition	Address domain	Function code	Byte count	Register value			CRC	
Byte	0	1	2	3	4~15	16	17	18
Content	0x01	0x03	0x0E	0x00	“YL0114010022”	0x00	0x19	0x66

Example of getting SN command response frame

Remarks: The probe SN is as follows, stored in ASCII format

Byte	4	5	6	7	8	9	10	11	12	13	14	15
Content	0x59	0x4C	0x30	0x31	0x31	0x34	0x30	0x31	0x30	0x30	0x32	0x32

SN of the probe

8.2.3 Start Measuring

Function: let the probe emit light continuously and start the measurement of dissolved oxygen value. Use MODBUS register 0x2500. The probe starts luminescence measurement when it is powered on by default.

Start register	Register quantity	MODBUS function code
0x2500	0x01	0x03

Start measuring Command Register Definition

The following takes the slave device address 0x01 as an example to illustrate the request frame and response frame of the start measurement command.

Definition	Address domain	Function code	Initial address		Register quantity		CRC	
Byte	0	1	2	3	4	5	6	7
Content	0x01	0x03	0x25	0x00	0x00	0x01	0x8F	0x06

Example of start measurement command request frame

Definition	Address domain	Function code	Byte count	Register Value	CRC	
Byte	0	1	2	3~4	5	6
Content	0x01	0x03	0x02	No meaning		

Example of start measurement command response frame

8.2.4 Get Temperature and DO Value

Function: Get the temperature and DO value of the probe: the unit of temperature is degrees Celsius, and the DO value is the value after user calibration, and the unit is % and mg/L.
The temperature and dissolved oxygen values of the probe can be read from 6 consecutive MODBUS registers starting at address 0x2600.

Start register	Register quantity	Register1,2	Register3,4	Register5,6	MODBUS function code
0x2600	0x06	TEMP value	DO value %	DO value mg/L	0x03

It is also possible to get each value individually.

Definition	Address	Register quantity	Byte
Temp value	0x2600H	2	4
DO % value	0x2602H	2	4
DO mg/L value	0x2604H	2	4

Get temperature and DO value Command Register Definition

Take the slave device address 0x01, the returned temperature value of 17.625, the DO value of 95.8%, 8.72mg/L as an example to illustrate the request frame and response frame for obtaining temperature and DO values commands.

Definition	Address domain	Function code	Initial address		Register quantity		CRC	
Byte	0	1	2	3	4	5	6	7
Content	0x01	0x03	0x26	0x00	0x00	0x06	0xce	0x80
	0x01	0x03	0x26	0x02	0x00	0x02	0x6e	0x83

Example of getting Temp and DO value command request frame

Definition	Address domain	Function code	Byte count	Register value			CRC	
Byte	0	1	2	3~6	7~10	11~14	11	12
Content	0x01	0x03	0x0C	17.625	0.958	8.72		
	0x01	0x03	0x04	0.958				

Example of getting Temp and DO value command response frame

Remarks: Temperature value, COD value, T value: little-endian storage mode, floating-point number

Temp value（17.625）				DO value（0.958）				DO value（8.72）			
0x00	0x00	0x8D	0x41	0x83	0x5B	0x75	0x3F	E8	88	0B	41

Temperature value and DO value byte distribution

8.2.5 Obtain Software and Hardware Version Numbers

Function: Get the currently used hardware version number and software version number.
The software and hardware version numbers of the probe can be read from two consecutive MODBUS registers whose starting address is 0x0700.

Start register	Register quantity	Register1	Register2	MODBUS function code
0x0700	0x02	hardware version number	software version number	0x03

Get hardware and software version number Command Register Definition

The following takes the slave device address 0x01, the returned hardware version 2.0, and the software version 5.7 as an example to illustrate the request frame and response frame of the command to obtain the software and hardware version numbers.

Definition	Address domain	Function code	Initial address		Register quantity		CRC	
Byte	0	1	2	3	4	5	6	7
Content	0x01	0x03	0x07	0x00	0x00	0x02	0xc5	0x7f

Example of getting hardware and software version command request frame

Definition	Address domain	Function code	Byte count	Register value				CRC	
Byte	0	1	2	3~4		5~6		7	8
Content	0x01	0x03	0x04	0x02	0x00	0x05	0x07	0xb9	0x19

Example of getting hardware and software version command response frame

8.2.6 Stop Measurement

Function: When the data is stable, you can stop the measurement, if you want to measure again, you need to send the start measurement command.
Use MODBUS register 0x2E00.

Initial address	Register quantity	MODBUS function code
0x2E00	0x01	0x03

Stop measurement Command Register Definition

The following takes slave address 0x01 as an example to illustrate the request frame and response frame of the stop measurement command.

Definition	Address domain	Function code	Initial address		Register quantity		CRC	
Byte	0	1	2	3	4	5	6	7
Content	0x01	0x03	0x2E	0x00	0x00	0x01	0x8D	0x22

Request frame for stop measurement command

Definition	Address domain	Function code	Byte count	Register value	CRC	
Byte	0	1	2	3~4	5	6
Content	0x01	0x03	0x02	No meaning		

Response frame for stop measurement command

8.2.7 Get User Calibration Parameters

Function: Obtain two calibration parameters K and B. (In order to prevent the deviation of dissolved oxygen value caused by factors such as probe aging, the calibration formula DO_{final}=K*DO +B, the general default value is: K=1;B=0.)
User calibration parameters K, B can be read from 4 consecutive MODBUS registers starting at address 0x1100

Start register	Register quantity	Register1, 2	Register3, 4	MODBUS function code
0x1100	0x04	K value	B value	0x03

Get user calibration parameters Command Register Definition

Definition	Address domain	Function code	Initial address		Register quantity		CRC	
Byte	0	1	2	3	4	5	6	7
Content	0x01	0x03	0x11	0x00	0x00	0x04	0x41	0x35

Request frame for obtain user calibration parameter command

Definition	Address domain	Function code	Byte count	Register value		CRC	
Byte	0	1	2	3~6	7~10	11	12
Content	0x01	0x03	0x08	1.0	0.0	0x9E	0x12

Response frame for obtain user calibration parameter command

Remarks: K, B: little-endian storage mode, floating-point number

K (3~6)				B (7~10)			
0x00	0x00	0x80	0x3F	0x00	0x00	0x00	0x00

Byte distribution of K and B values

8.2.8 Set User Calibration Parameters

Function: Set two calibration parameters K and B.

The user calibration parameters K and B can be set through four consecutive MODBUS registers starting at 0x1100.

Start register	Register quantity	Register1, 2	Register3, 4	MODBUS function code
0x1100	0x04	K value	B value	0x10

Set user calibration parameters Command Register Definition

The following takes the slave device address 0x01, K=1.0, B=0.0 as an example to illustrate the request frame and response frame of the user calibration parameter command.

Definition	Address domain	Function code	Initial address		Register quantity		Byte count	Register value		CRC	
Byte	0	1	2	3	4	5	6	7~10	11~14	15	16
Content	0x01	0x10	0x11	0x00	0x00	0x04	0x08	1.0	0.0	0x81	0xAE

Request frame for set user calibration parameter command

Remarks: K, B: little-endian storage mode, floating-point number

K (7~10)				B (11~14)			
0x00	0x00	0x80	0x3F	0x00	0x00	0x00	0x00

Byte distribution of K and B values

The following takes the slave device address 0x01, the returned K=1.0, B=0.0 as an example to illustrate the request frame and response frame for obtaining the user calibration parameter command.

Definition	Address domain	Function code	Initial address		Register quantity		CRC	
Byte	0	1	2	3	4	5	6	7
Content	0x01	0x10	0x11	0x00	0x00	0x04	0xc4	0xf6

Request frame for set user calibration parameter command

8.2.9 Set Fluorescent Cap Parameters

Function: Set the probe fluorescent cap parameters (K0~K7), used when replacing the fluorescent cap.

The probe fluorescent cap parameters can be set through 16 consecutive MODBUS registers starting at address 0x2700.

Initial address	Register quantity	Register1~16	MODBUS function code
0x2700	0x10	K0~ K7	0x10

Set fluorescent cap parameters Command Register Definition

The following takes slave device address 0x01 as an example to describe the request frame and response frame of the command to set fluorescent cap parameters.

Definition	Address domain	Function code	Initial address		Register quantity		Byte count	Register value	CRC	
Byte	0	1	2	3	4	5	6	7~38	39	40
Content	0x01	0x10	0x27	0x00	0x00	0x10	0x20	K0~K7	XX	XX

Request frame for set fluorescent cap parameter command

Remarks: Ki(i=0~7) fluorescent cap parameters: little endian storage mode, floating point number

Definition	Address domain	Function code	Initial address		Register quantity		CRC	
Byte	0	1	2	3	4	5	6	7
Content	0x01	0x10	0x27	0x00	0x00	0x10	0xcb	0x71

Response frame to set fluorescent cap parameter command

8.2.10 Get Slave ID

Function: Get the MODBUS slave device address of the current electrode, this command uses 0xFF as the fixed address field

The MODBUS slave device address of the current electrode can be read from the MODBUS register whose starting address is 0x3000.

Initial address	Register quantity	Register1	MODBUS function code
0x3000	0x01	Current device address	0x03

Get slave ID Command Register Definition

The following takes the returned address 0x03 as an example to illustrate the request frame and response frame for obtaining the slave ID command.

Definition	Address domain	Function code	Initial address		Register quantity		CRC	
Byte	0	1	2	3	4	5	6	7
Content	**0xFF**	0x03	0x30	0x00	0x00	0x01	0x9E	0xD4

Request frame for get slave ID command

Definition	Address domain	Function code	Byte count	Register value		CRC	
Byte	0	1	2	3	4	5	6
Content	0xFF	0x03	0x02	0x03	0x00(Reserve)	0x91	0x60

Response frame for get slave ID command

8.2.11 Set Salinity Value

Function: Set the salinity of the probe, the unit is ‰, and the default salinity is 0. This setting is saved when power off.

The salinity can be set by 2 consecutive MODBUS registers starting at address 0x1500.

Initial address	Register quantity	Register1	MODBUS function code
0x1500	0x02	Salinity	0x10

Set salinity value Command Register Definition

The following takes slave device address 0x01 as an example to illustrate the request frame and response frame of the salinity setting command.

Definition	Address domain	Function code	Initial address		Register quantity		Byte count	Register value	CRC	
Byte	0	1	2	3	4	5	6	7~10	11	12
Content	0x01	0x10	0x15	0x00	0x00	0x02	0x04	Salinity	XX	XX

Request frame for setting salinity value command

Remarks: Little-endian storage mode, floating point

Definition	Address domain	Function code	Initial address		Register quantity		CRC	
Byte	0	1	2	3	4	5	6	7
Content	0x01	0x10	0x15	0x00	0x00	0x02		

Response frame for setting salinity value command

8.2.12 Set Atmospheric Pressure

Function: Set the atmospheric pressure of the probe, the unit is kpa, the default is the standard atmospheric pressure 101.325kpa, the setting is saved after power off.
The atmospheric pressure can be set through 2 consecutive MODBUS registers starting at address 0x2400.

Initial address	Register quantity	Register1~2	MODBUS function code
0x2400	0x02	Atmospheric pressure	0x10

Set atmospheric pressure Command Register Definition

The following takes slave device address 0x01 as an example to describe the request frame and response frame of the command to set atmospheric pressure.

Definition	Address domain	Function code	Initial address		Register quantity		Byte count	Register value	CRC	
Byte	0	1	2	3	4	5	6	7~10	11	12
Content	0x01	0x10	0x24	0x00	0x00	0x02	0x04	Atmospheric pressure	XX	XX

Request frame for setting atmospheric pressure command

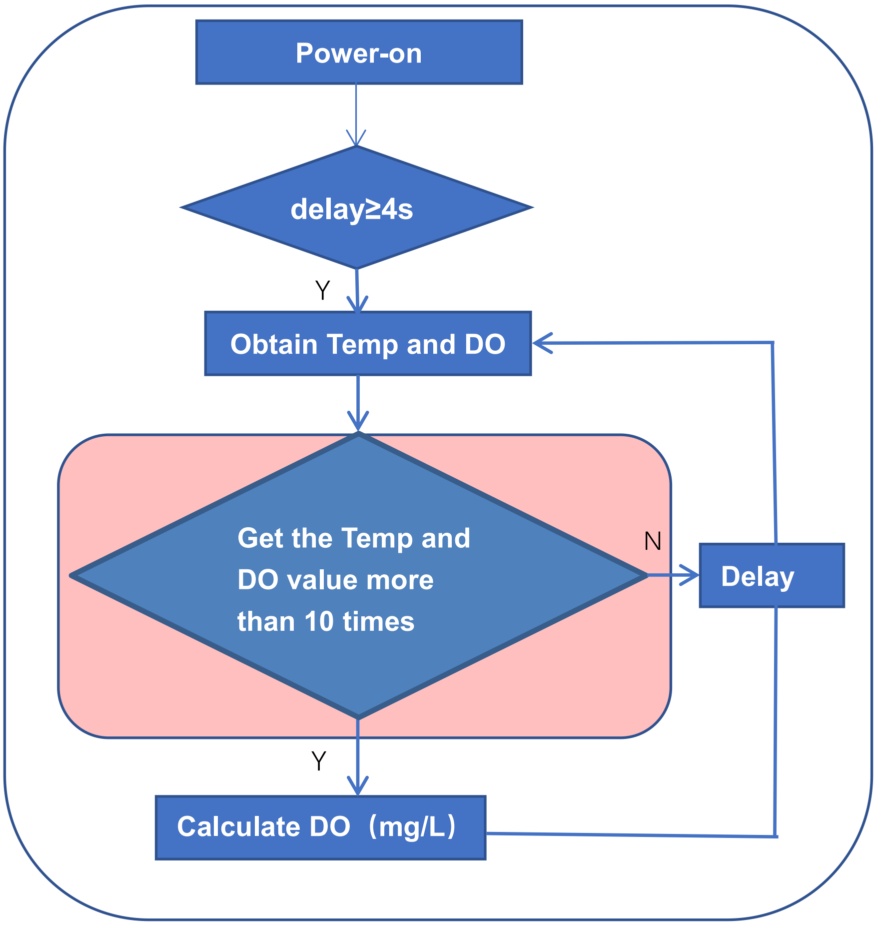
Remarks: Little-endian storage mode, floating point

Definition	Address domain	Function code	Initial address		Register quantity		CRC	
Byte	0	1	2	3	4	5	6	7
Content	0x01	0x10	0x24	0x00	0x00	0x02		

Response frame for setting atmospheric pressure command

8.3 Obtaining Dissolved Oxygen Value Process

Processing flow | **Corresponding frame command**



Obtain temp and DO value

Note: The meaning represented by the red part in the flow chart is that the user is advised to obtain the temperature and dissolved oxygen values 10 times and calculate the average value, and then perform the conversion from DO (%) to DO (mg/L).

Calculate DO (mg/L), that is, convert DO (%) into DO (mg/L)

According to the formula DO(mg/L)=DO(%)*X1*X2*1.4276;

where 1 ml/L = 1.4276 mg/L;

InX1= AI + A2 100/T + A3 In T/1OO + A4 T/100 + S* [B1 + B2 T/100 + B3 (T/100)^2];

where AI = -173.4292, B1 = - 0.033096,

A2 = 249.6339, B2 = 0.014259,

A3 = 143.3483, B3 = - 0.001700;

A4 = -21.8492;

T =273.15 + t, T is the absolute temperature, t is the temperature in Celsius;

S is salinity, pure water, S=0;

X2= (Phmg - u) / (760 - u);

Wherein Phmg= pressure * 760 / 101.325, pressure is the air pressure value, the unit is kpa;

Logu= 8.10765 - (1750.286/ (235+t)), t is the temperature in Celsius.

Below is the reference code

```
#include <math.h>

float pressure = 0.0;
float Phmg= 0.0;
float t = 0.0;
float T = 0.0;
float S = 0.0;

T = 273.15 + t; //t is the current temperature
X1' = -173.4292 // X1' = In X1 according to the above classical formula
      + 249.6339*(100/T)
      + 143.3483*log(T /100) //log() function is In(x)
      + -21.8492*(T /100)
      +S*(-0.033096 + (0.014259* T)/100
      -0.001700*( T /100)*( T /100));
X1 = exp(X1'); //natural logarithm

// log u = 8.10765 - (1750.286/ (235+t))
u' = 8.10765 - (1750.286/ (235 + t));// u' = log u
u = pow(10, u');                         //u=10^u'

Phmg = pressure*760/101.325;
X2 = ((Phmg - u)/(760 - u));
DO(mg/L)= DO(%)*X1*X2*1.4276;
```