






【Sensor Model Overview】

Sensor Model	Key Features	Physical Appearance	Application Scenario
DO-S2	Dual-channel dissolved oxygen measurement		Suitable for various water environments
DO-S4	Real-time measurement with high value for money and customizable design		For regular fish ponds, universally applicable to seawater and freshwater
DO-S5	Handheld fast measurement		Designed as a handheld device for both marine and freshwater use
DO-S6	All-plastic housing online dissolved oxygen sensor		Suitable for aquaculture, wastewater, seawater, and freshwater
DO-S20	Online tri-sensor with all-plastic enclosure for DO + pH + temperature		Applicable to aquaculture, sewage, saltwater, and freshwater

2. Technical

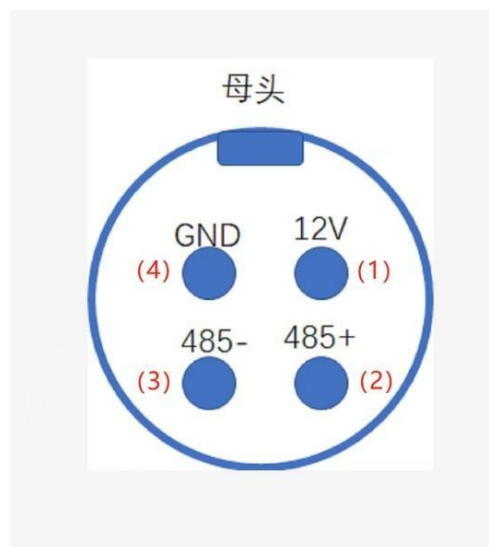
Parameter	S-parameter S2	S-parameter S4	S-parameter S5	S-parameter S6	S-parameter S20
Measurement Range (Dissolved Oxygen)	0-20mg/L (ppm)				
	0-200% saturation				
Measurement Accuracy (Dissolved Oxygen)	Less than 5ppm: ± 0.2 ppm (0.2mg/L)				
	Higher than 5ppm: ± 0.3 ppm (0.3mg/L)				
Repeatability (Dissolved Oxygen)	0.2ppm (0.2mg/L)				
Response Time (Dissolved Oxygen)	T90<60 seconds	T90<60 seconds	T90<60 seconds	T90<60 seconds	T90<60 seconds
Dissolved Oxygen Recovery under Isothermal Conditions < 0.1 mg/L	Stable 300S	Stable 200S	Stable 100S	Stable 200S	Stable 300S
Dissolved Oxygen Recovery under Temperature Shock Conditions < 0.1 mg/L	Stable for 2 hours	Stable for 1 hour	Stable for 30 minutes	Stable for 1 hour	Stable for 2 hours
Measurement Range (Temperature)	0-40°C				
Measurement Accuracy (Temperature)	± 0.1 °C				
Response Time (Temperature)	T80<600 seconds	T80<300 seconds	T80<30 seconds	T80<300 seconds	T80<600 seconds
PH Measurement Range	-				4-11
PH Value Accuracy	-				0.1
Storage Temperature	-5 - 50°C (moisturize)				
Communication Interface	RS485 (baud rate 9600).				
Communication Protocol	ModbusRTU				
DC Power Supply Requirements	12V(≥ 1 A)	12V-24V	12V-24V	12V-18V	12V-24V

Power Consumption	Measured power consumption of 20mA Motor current: Start the 1000mA@12V Work 300mA@12V	20mA@12V	20mA@12V	20mA@12V	20mA@12V
Reliable Lifetime	Dissolved oxygen for 2 years				Dissolved oxygen for 2 years
Waterproof Depth	10 meters				

3. Material

Subassembly	Material
Housing	ABS/PC 304 316 stainless steel
Tail line	TPU/PVC

4. Wiring



Serial number	Color	Definition
1	Red	power supply+
2	Green	A(485+)
3	Yellow	B(485-)
4	Black	power supply-

Note: The deprecated wiring methods are as follows

2020, red (12V), green (A), blue (B), and black (GND) were used

2021, red (12V), green (GND), yellow (B), and black (A) were used

5. Precautions for installation

Note: Please be sure to read this carefully

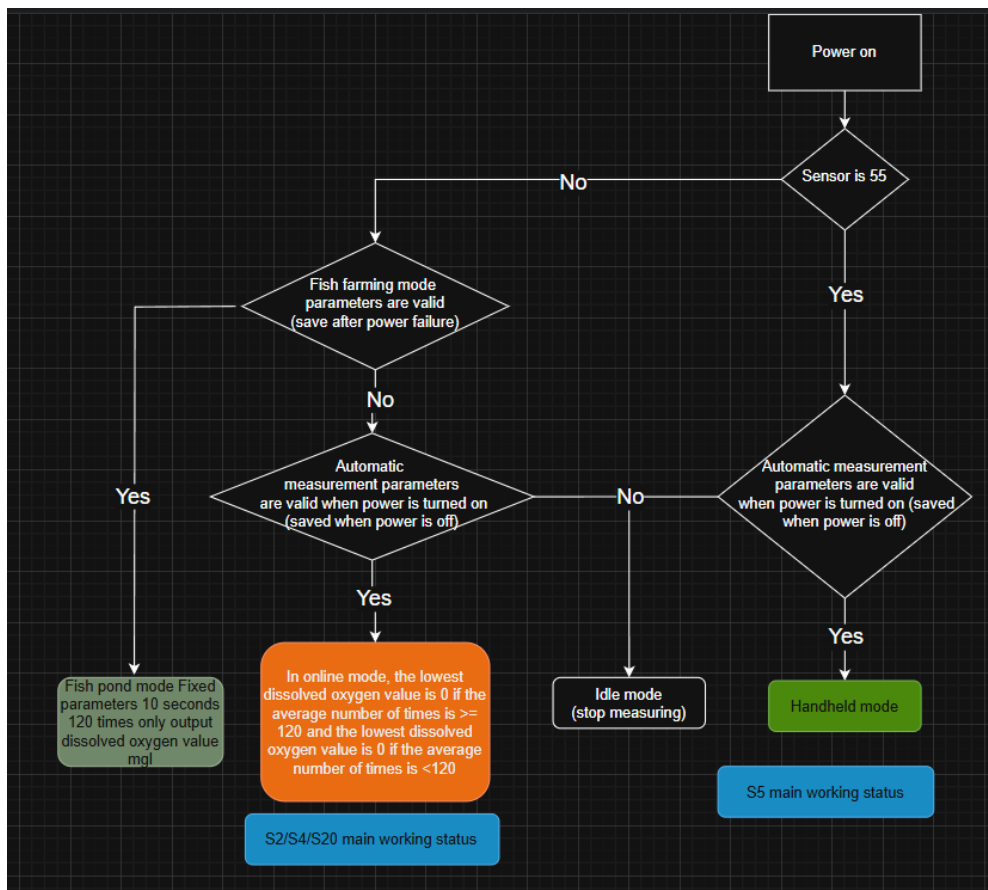
- Keep the waterproof connector above the water surface as much as possible, and never

immerse yourself in water for a long time

- The measurement depth is about 20cm by default
- Be sure to ensure that the measurement sensitive membrane is clean and intact without damage (if it is contaminated, **please use a soft cloth and water gently.**)

6. Description of the sensor's operating mode

- Online mode: suitable for long-term online measurement equipment scenarios (controllers).
- Fish pond mode: suitable for professional breeding scenarios (fish pond environment) This mode only outputs dissolved oxygen value mg/l
- Handheld mode: suitable for scenarios such as handheld instruments (handheld).
- Idle mode: the sensor stops measuring



7. Modbus communication content

7.1. Hardware Conditions

Use a generic oneThe RS485 Modbus protocol operates sensors and access registers.

- Communication baud rate 9600
- Format 8 data bits without parity bits, 1 stop bit
- IEEE 754 Floating-Point Format Standard. For reference, consult IEEE 754 Standard documentation and utilize the online calculation tool:

<https://lostphp.com/hexconvert/>

- Check the CRC16/MODBUS refer to the MODBUS related documents. Online Calculation Tools:

<http://www.ip33.com/crc.html>

7.2. Common Communication Protocol Standards

Note: Please refer to the protocol standard for specific content

1. [National Standard Modbus File - Modbus Protocol National Standard Specification GBT_19582-1 2008.pdf](#)»
2. [Simplified commercial version of Modbus documentation - "MODBUS communication protocol \(RTU transmission mode\)".pdf](#)»

Quick overview of the agreement

MODBUS definition for data transfer

	Device address	Feature codes	Data	Sum check	
numeric value	1-119	Feature codes	Data	CRC L	CRC H
byte	1	1	n	1	1

The dissolved oxygen sensor transmission unit utilizes two MODBUS function codes:

0x03: Read Holding Registers

0x10: Write Multiple Registers

Read register content distribution

	Address	Feature codes	Number of bytes	Byte0	Byte1	Byte2	Byte3	Register...	CRC_H	CRC_L
				Register 0		Register 1				
Byte		0x03	4N	0x12	0x34	0x56	0x78	...		
Word				0x1234		0x5678				
Double word				0x12345678						

Error codes

Exception response packets have two different domains from the normal response:

- **Function Code Field:** In a normal response, the returned function code is identical to the requested function code. In an exception response, the Most Significant Bit (MSB) of the returned function code is set to 1.

For the Read Holding Registers command (0x03), the corresponding exception response function code is 0x83;

For the Write Multiple Registers command (0x10), the corresponding exception response function code is 0x90.

Error Response Data Field Definition:

Code	Name	Meaning
1	Illegal feature codes	The slave receives a code that cannot execute a function. When a query command is issued, the code indicates that the program is not functional.
2	Invalid data addresses	The received data address is the address that is not allowed by the slave.
3	Illegal data	The value of the query data area is not allowed from the machine.
4	The slave device is faulty	An unrecoverable error occurred while the slave performed the action requested by the host.
5	Confirm	The slave has received the request to process the data, but it takes a long time to process, and the confirmation is sent to avoid a timeout error on the host Recognize the response. The master then sends another "query

		complete", which does not determine whether the slave has completed processing.
6	The slave is busy	The slave is busy processing a long-running program command that asks the master to send information when the slave is idle.
7	Negation	When the slave device cannot execute the program function requested by the query, it returns a "programming request not acknowledged" message to the master using decimal code 13 or 14. The master should then request diagnostic error information from the slave.
8	Memory Parity Error	When the slave device detects a parity error while reading data from extended memory, the master resends the data request as requested by the slave.

查询:

Addr	Fun	DO start reg hi	DO start reg lo	DO #of regs hi	DO #of regs lo	CRC16 Hi	CRC16 Lo
0AH	01H	04H	A1H	00H	01H	XXH	XXH

响应 (不正常或例外):

Addr	Fun	Exception Code	CRC16 Hi	CRC16 Lo
0AH	81H	02H	XXH	XXH

图 3-1. 不正常信息帧格式

7.3 Custom Protocol for Dissolved Oxygen Sensor

Broadcast query address

Obtain the current sensor device address via the broadcast address (0xFF)

Host sends:

定义	地址域	功能码	起始地址		寄存器数量		CRC	
字节	0	1	2	3	4	5	6	7
内容	0xFF	0x03	0x00	0x0A	0x00	0x02	0xF1	0xD7

Device responds:

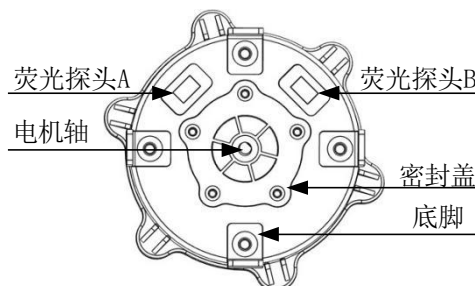
定义	地址域	功能码	字节数	寄存器值				CRC	
字节	0	1	2	3	4	5	6	7	8
内容	0xFF	0x03	0x04	0x00	0x02	0x00	0x04	0x44	0x3C
				Reg0: 当前设备地址 2		Reg1: 传感器类型 S4			

Explanation:

- Host sends with address field set to 0xFF
- Byte 4 represents the device address; in the example, the sensor address is 2
- Byte 6 represent the device type; in the example, the sensor type is S4
- If the sensor address is unknown, this command can be used to retrieve it
- This command is only applicable when there is a single sensor connected on the RS-485 bus; multiple sensors responding simultaneously will cause interference in the RS-485 data

※ S2 Explanation (only for DO-S2)

DO-S2 contains two fluorescence dissolved oxygen probes within a single housing. In practical use, you can choose to access different probes. By comparing the readings from both probes, you can determine the reliability of the measurement data.



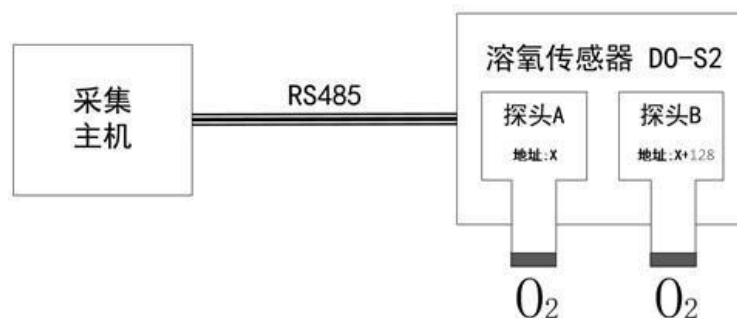
- The measurement structures of the two probes are completely independent, with only the

communication part being shared.

- The two probes are logically independent, with Modbus access addresses differing by 128 (decimal).

For the second probe, each time you read, it returns the address of the first channel (add1). To get the second channel's address, add 128 to the first channel address. For example, if the read address command returns address 2, the second channel's address will be 130.

- The Modbus address can only be set for Probe A, while the address of Probe B follows by adding +128.



Except for the address register, each parameter needs to be set and read separately.

- During normal use, due to the continuous changes in the water environment, when the dissolved oxygen is not exceptionally high, a difference of up to 1 mg/L (10%) between the two probes is considered normal. If the difference is too large, please contact our company for support.

7.4.Register Table

	Register Name	Address (Decimal)	Register Quantity	Read /Write	Read Content Description (4 bytes)	Write Content Description (4 bytes)	Explanation
Operating Parameter Settings Class	Online Mode (S5 not supported) (No retention after power loss)	0	2	R/W	Reg0: Measurement Duration (5-10 seconds) Reg1: Calculation Count (10-180 times) When both Reg0 and Reg1 are set to 0, measurement will stop.		Measurement Cycle: Measure once and update data every x [5-10] seconds. Recommended: 10 seconds. Average Count: The number of times data undergoes a sliding average. A higher number smooths the data more, but slows the response. Recommended: 120 times, i.e., averaging the last 120 data points. Note : <ol style="list-style-type: none"> The contents of this register are not saved after power loss; it will restore to the "Power-on Automatic Measurement" parameters after power is restored. Online/handheld modes are mutually exclusive, with the last set mode being applied. S5 does not support the current mode; writing a non-zero value will result in an error. When the calculation count is >= 120 times, it enters the "Tulang" mode, and the minimum dissolved oxygen ratio & dissolved oxygen value will be 0.1.
	Handheld Mode (S2 not supported) (No retention after power loss)	2	2	R/W	Reg0: Measurement Duration (5-60 minutes) Reg1: Calculation Count (1-180) When both Reg0 and Reg1 are set to 0, measurement will stop.		The "Handheld Mode" command sets the sensor to measure at a rate of once per second. After operating for the specified time, it exits measurement. Measurement Duration : Measurement will stop after 5-60 minutes. Writing the command again will reset the timer. Average Count : The number of times data undergoes a sliding average, range (10-180). The higher the number, the smoother the data, but it will slow down the response time. Recommended: 30 times. Note : <ol style="list-style-type: none"> This register does not save data after power loss; S5 will restore to the "Power-on Automatic Measurement" parameters after power-up.

					<p>2. Online/Handheld modes are mutually exclusive, with the last set mode being applied.</p> <p>3. S2 does not support the current mode; writing a non-zero value will result in an error</p> <p>4. S5 Reg0 does not apply for measurement duration, and S5 can continuously measure without exiting</p>
Altitude	4	2	R/W	Reg0: Range 0-8848 meters Reg1: Empty (0)	The average atmospheric pressure for the location, calculated indirectly via altitude, is used to compensate the calculation of dissolved oxygen values (mg/L). Starting from the version released in August 2023, the contents of this register are saved after power loss.
Salinity (PSU)	6	2	R/W	Reg0: Range 0-100 Reg1: Empty (0)	The salinity value is obtained through a lookup table and is used to compensate the calculation of dissolved oxygen (mg/L). Starting from the version released in August 2023, the contents of this register are saved after power loss.
Motor Operation (No retention after power loss)	8	2	R/W	Reg0: Motor Operating Mode 0: Stop working 1: Timed automatic cleaning 2: Rotate once (Continuous control requires at least a 10-minute interval) Reg1: Timed Automatic Cleaning Cycle (Effective only when the motor operating mode is set to 1; for other modes, write 0) Range: 10-240 minutes	Only S2 supports this feature. After setting the "Power-on Automatic Measurement" parameter on S2, the motor mode will automatically be set to 1. The timing cycle is 15 minutes. To avoid current overload when multiple S2 devices power on simultaneously, S2 will randomly delay (0-10 seconds) before starting to work after power-up.

Configuration Class (Saved after power loss)	Device Address	10	2	R/W	<p>Before the 2023.4.1 version:</p> <p>Reg0: Address [Range 1-119]</p> <p>Reg1: Empty (0)</p> <p>After the 2023.4.1 version: (Please provide the details for the new version if available, and I can help you with the updated information.)</p>	<p>If the address is unknown, first use the broadcast to query the address, and then set the address.</p> <p>For S2, the second channel address is the first channel address plus 128.</p>
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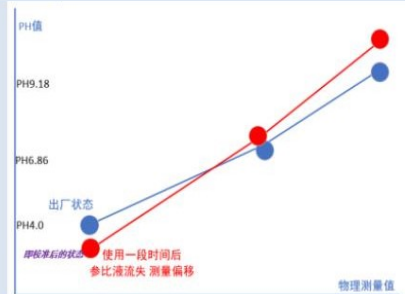
					<p>Reg0: Address [Range: 1-119] Reg1: Sensor Type [Range: 0/2/4/5/6/20/21] [Read-only] 0: Old version, not set 2: S2 (Dual-channel online motor version) 4: S4 (Single-channel online version) 5: S5 (Single-channel handheld version) 6: S6 (Single-channel online upgraded version) 20: S20 (Single-channel DO & pH online version) 21: S21 (Single-channel pH version)</p>	
Power-on Automatic Measurement (Saved after power loss)	12	2	R/W	<p>Non-S5 (Online Mode Parameters) Reg0: Measurement Duration (5-10 seconds) Reg1: Calculation Count (10-180) S5 (Handheld Mode Parameters) Reg0: Measurement Duration (60 minutes) Reg1: Calculation Count (1-180)</p> <p>When both Reg0 and Reg1 are set to 0, it indicates the shutdown of the power-on automatic measurement function.</p>	<p>S2/S4/S6/S20: After configuring this parameter, automatic online measurement will start when powered on. S5: After configuring this parameter, automatic handheld measurement will start when powered on.</p> <p>Note: This register's content is saved. For S4/S6/S2/S20, after powering on, the automatic online mode measurement will proceed according to this parameter. [Tulang recommended parameter: 10 seconds / 120 times] For versions after January 2024, S5 will automatically start handheld mode measurement after power-on. [Recommended: 60 minutes / 30 times]</p>	

Operation Class	Dissolved Oxygen Calibration Operation	14	2	R/W	<p>Byte0: Calibration Flag 0: Calibration completed</p> <p>1: Calibration in progress</p> <p>Byte1: Zero Oxygen Calibration Valid Flag (Effective when measurement is completed)</p> <p>0: Zero oxygen calibration invalid</p> <p>1: Zero oxygen calibration valid</p> <p>Byte2: Saturation Oxygen Calibration Valid Flag (Effective when calibration is completed)</p> <p>0: Saturation oxygen calibration invalid</p> <p>1: Saturation oxygen calibration valid</p> <p>Byte3: (Effective when calibration is in</p>	<p>1: Start zero oxygen calibration 2: Start saturation oxygen calibration 3: Exit calibration (during calibration) 4: Clear saturation oxygen calibration value 5: Clear zero oxygen calibration value</p> <p>Please first read the "Sensor Accuracy Verification Method and Calibration Operation Instructions."</p> <p>In practical use, you can either calibrate only the saturation oxygen point (single-point calibration) or calibrate both the saturation oxygen point and the zero oxygen point (two-point calibration).</p> <p>Note: When performing two-point calibration, you must first calibrate the zero oxygen point, and then calibrate the saturation oxygen point.</p>
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					progress) Countdown of calibration in progress (minutes)	
Data Reading Class	Temperature	16	2	R	<p>Reg0 and Reg1 are both temperature values, represented differently. Unit: °C, Range: -10~50°C</p> <p>Reg0: Unsigned short integer Reg0 = (uint16_t)((actual temperature + 50) * 10)</p> <p>Reg1 would represent the same value, but in a different format. Let me know if you need the specific calculation for Reg1!</p>	<p>Not supported</p> <p>Reg0: After adding 50°C, the value is magnified 100 times</p> <p>4000: -10°C</p> <p>7521: 25.21°C</p> <p>9001: 40.01°C</p> <p>Reg1: The value is magnified 100 times</p>

					Reg1: Signed short integer Reg1 = (int16_t)(actual temperature * 100)	-10000: -10°C 2521:25.21°C 4001:40.01°C
	Dissolved oxygen value	18	2	R	Reg0: Dissolved oxygen ratio, unit: %, range: 0~25000 [0%~250%] Reg1: Empty (0)	Temperature output range -10~50°C Output -25°C indicates that a reading was taken before temperature measurement started after power-on. Please set the online mode to start measurement. Magnify the value by 100 times. Can only be used when status bit0 is valid. When the value is 65535, it indicates a measurement fault. Please check the measurement flag bit / after-sales.
	Dissolved oxygen ratio	20	2	R	Reg0: mg/L, 范围 range: 010000 [0100 mg/L] Reg1: Empty (0)	Magnify the value by 100 times. Can only be used when status bit0 is valid. When the value is 65535, it indicates a measurement fault. Please check the measurement flag bit / after-sales
						Measurement countdown: This register's value is valid when Bit0 (data valid flag) in the measurement flag bit is 0. The value represents the time (in seconds) until the next valid data

	Status bits	22	2	R	Reg0: Measurement countdown Reg1: Measurement flag bits	<p>Measurement flag bits (Bit0-Bit15): Software status-class-----</p> <p>Bit0: Data valid flag bit 1: Indicates that the dissolved oxygen data has been updated. 0: Indicates that the dissolved oxygen data has not been updated and is the previous measurement data. This bit automatically resets to 0 after valid dissolved oxygen data is read. During operation, the host can periodically query this bit to determine whether to read the dissolved oxygen data. Note: Temperature information is valid in real-time; each reading is the real-time temperature.</p> <p>-----Warning class----- -----</p> <p>Bit1: Measurement anomaly warning Power interference or membrane detachment warning flag is set. When this bit is 1, please check if the power supply and membrane are normal. If the problem persists after troubleshooting, please return the device to the factor</p> <p>Bit2: Motor overload anomaly flag bit [S2 only] When this bit is 1, it is necessary to check if the brush is stuck by foreign objects. If the problem persists after troubleshooting, please return the device to the factory.</p> <p>Bit3: Membrane life warning When this bit is 1, it indicates that the membrane lifespan is about to expire. It is recommended to replace the sensor within 1 week.</p> <p>Bit4: Real-time clock anomaly [S27 only] For issues involving activation, it is recommended to return the device to the factory.</p>
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							<p>Bit5: Calibration parameter abnormality When this bit is 1, return to the factory immediately.</p> <p>Bit6: Temperature measurement unit abnormality</p> <p>Bit7: Dissolved oxygen calibration failed, please check the calibration environment and recalibrate/after-sales</p> <p>-----Not used-----</p> <p>Bit8~Bit15: Unused</p>
Read letter Interest	Software Version	24	2	R	<p>Byte0: Year (e.g. 21 is 2021)</p> <p>Byte1:Month</p> <p>Byte 2: Day</p> <p>Byte3: time</p> <p>For example, the four</p>	Not supported	<p>Example: The four bytes are {21,12,15,11} It means 11:00 on December 15, 2021</p>
	Hardware version	26	2	R			
	Factory version	28	2	R			
	Sensor working time	30	2	R	<p>reg0: measurement duration (unit: hours)</p> <p>reg1: Led working time (unit: seconds)</p> <p>Versions after 2023.7.113</p> <p>reg0: measurement duration (unit: hours)</p> <p>reg1: reserved</p>		<p>The sensor records once every 4 hours of operation.</p>
	SN	32	6	R	12 bytes SN, high bit first		
Reading number According to the category	Measuring pH	38	2	R	<p>reg0:m-aazmed magnified 1000 times</p> <p>pH value</p> <p>Value ange: 0~14000 [PI-I: 0~14*0]</p> <p>reg1: valid status [1 valid/0 invalid]a</p>	<p>Only supported on S20</p>	<p>Exalpnle: 0X2030355 64 14E5004004B00 1D</p> <p>The software version is supported after March 1 , 2024</p> <p>When the 82X sta1ts the dissolved oxygen measurement, the pH measurement starts simultaneously.</p> <p>The register is an integer that is magnified 1000 times the PH.</p> <p>For example: a reading of 7100 actually represents a pH value of 7.100 (pH value accuracy is 0.1)</p>
Operational Class	pH Calibration Operation	40	2	RW	<p>Byte0: Calibration process [0: Calibration completed]</p> <p>[1: PH4.00 calibration in progress]</p> <p>[2: PH 6.86 calibration in progress]</p> <p>[3: PH9.18 calibration in progress]</p> <p>Byte1: PH4.00 calibration valid flag</p> <p>Byte2: PH 6.86 calibration valid flag</p> <p>Byte3: PH 9.18 calibration valid flag</p> <p>0: No calibration data</p> <p>1: With calibration data</p>	<p>Only supported on 820</p> <p>Calibration Operation</p> <ol style="list-style-type: none"> 1 Start pH4.00 calibration 2 Clear PH4.00 calibration 3 Start pH6.86 calibration 4 Clear PH6.86 calibration 5 Start pH9.18 calibration 6 Clear PH9.18 calibration 	<p>pH Multi-point Calibration Operating Instructions</p> <p>Due to physical properties, the electrode slope and zero potential of the pH electrode will drift slightly after soaking. I</p> <p>Refer to the document < PH Calibration Metho d> to calibrate the red state in the figure below to the blue</p>  <p>When PH needs after-sales service, please clear the three-point calibration value and correction value and then measure it under the standard solution. If the error is large, please contact after-sales service.</p>

Operational	Reset to Factory Defaults	42	2	R/W KEY			<p>The software version is supported after April 1, 2024</p> <p>Restore factory settings: Write the key (0X234567 8 9) and execute</p> <p>Recovery parameters: Address is 1 Altitude and salinity are 0 Automatically measure parameters after power on (10* 120 for non-SS) (60* 1 0 for S5) The motor rotates every 15 minutes (only supported by 82) Clear Zero Oxygen & Saturated Oxygen Calibration Clear PH4.00/PH6.86/PH9.18 calibration (only supported by S20/S21) Turn off fish pond mode</p>	
Operational Class	Fislrpond Mode (Not supported on S5)	44	2	RW	<p>Reg0: Fish pond mode control command 0: Single-time on [not saved when power off] 1: Single-time off [not saved when power off] 2. Always on [Save on power failure] 3. Always off [Save on power failure] [Factory default] regl:enlpty(0)</p>		<p>The software version is supported after July 1, 2024 U K</p> <p>Only used for fish pond farming scenarios</p> <p>This parameter is saved after power failure If the parameter is effective, non-SS sensors will enter this mode first after power-on.</p> <p>If the fish pond mode is activated, the fish pond mode will be turned off once when entering the online mode or handheld mode</p> <p>Note: After enabling the fish pond mode, measurements start with fixed parameters of 120 times in 10 seconds.</p>	
Read letter Interest	Product serial number information (Factory serial numbers are not repeated)	46	2	R	<p>Reg0: Batch (Year and month of production) Reg1: Production serial number (production serial number)</p>	Not supported	<p>In this mode, the dissolved oxygen ratio (%) value is always 0, and the dissolved oxygen value (mgL) value is output normally.</p> <p>The software version is supported after July 1, 2024</p> <p>The barcode on the sensor label is 240603456 Batch: 2406</p>	
OTP area	Starting working time	48	2	R/W	<p>Byte0: Year H8 Byte 1: Year L8 Byte2: Month Byte3: Day For example, {7,229,12,28} means December 28, 2021</p>		<p>Sensor ID: 03456</p> <p>The software version is supported after July 1, 2024</p> <p>Used to record the time when the crurent sensor is used for the first time, written by the controller on the fish pond. When all the data read are 0 , it can be written, and it can only be written once.</p> <p>Note: There is no limit on the size of the form-byte value. Users can enter custom content formats, such as writing product activation passwords.</p>	
Operational Class	PH correction operation Only supported on S20/S21	50	2	R/W	<p>Byte0: Correction flag [0:Uncorrectedy] [1 : Corrected] Byte1: 0 (reserved) Byte2: 0 (reserved) Byte3: 0 (reserved)</p>	<p>Corrective Action [Range: 0~141] 0 Corrected to 0.0 1 Corrected to 0.1 2 Corrected to 0.2 40 revised to 4.0 ... 68 corrected to 6.8...</p>	<p>The key is used for authentication.</p> <p>The software version is supported after July 1, 2024</p>	

						92 corrected to 9.2 ... 140 Corrected to 14.0 141 Clear correction value	Correction is to add the correction value to the current measurement result and calibrate it to the value of the current correction fluid Note: The correction value is added to the entire measurement range. It needs to be stable in the correction fluid for more than 1 minute before starting. It can be accurately corrected in standard solution (recommended), or fuzzy correction can be performed using pH test paper. For example, if the current liquid is PH7, after writing 70, the PH value will be 7.0. For example, if the current liquid is PH8, after writing 80, the PH value will be 8.0. When PH needs after-sales service, please clear the three-point calibration value and correction value and then measure it under the standard solution. If the error is large, please contact after-sales service.
Informational	Product information (ID not repeated) 【Migrate to register 46】	4608	2	R	Reg0: Batch (year and month of production) Reg1: Sensor ID (production serial number)	Not supported	The barcode on the sensor's outer label is 220103456. Batch: 2201 Sensor ID: 03456
Informational	version information	4610	2	R	Reg0: Firmware version number		Firmware version number: H8 major version number L8 minor version
OEM	Starting working time 【Migrate to register 48】	4624	2	R/W	Byte0: Year H8 Byte1: Year L8 Byte2: Month Byte3: Day For example, the four bytes are {7,229,12,28} Indicates December 28, 2021	Not supported	Used to record the timestamp of the sensor's first use, written by the controller on the fish farm. Writing is only permitted when the value read is 0, and it can only be written once.

Note: With the exception of the Reg1 register for temperature, all other registers are unsigned numbers (uint8_t, uint16_t, uint32_t).

Salinity Specification

PSU (Practical Salinity Units) is the standard unit for expressing salinity in oceanography. It is a dimensionless quantity, typically represented in ‰ (per mille). The average salinity of seawater is 34.7‰, which translates to "Practical Salinity Standard" or "Practical Salinity Unit Standard"

PSS (Practical Salinity Scales) also represents the standard for salinity. The fundamental definition of salinity is the mass in grams of dissolved substances per kilogram of water.

Drinking Pure Water: EC = 1~10 μ S/cm (National Standard). Seawater Conductivity = 40~48 mS/cm.

Based on the conductivity value (mS/cm) Measured Salinity (PSU)

mS/cm	0	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
PSU	0	3	4	4	5	6	6	7	8	8	9	10	10	11	12	13	13	14	15	15	17	17
mS/cm	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	42	44	46	48	50	52	54
PSU	18	18	19	20	21	22	22	23	24	25	25	26	27	28	29	30	32	33	35	37	38	40

8. Communication frame example

- Read device address

Send: FF 03 00 0A 00 02 F1 D7

Receive: FF 03 04 00 01 00 02 35 FD [Read address 1 type S2]

- Set online mode [set to 120 times in 10 seconds] [[recommended parameters for fish pond farming scenarios](#)]

Send: 01 10 00 00 00 02 04 00 0A 00 78 D3 8F [measurement interval 10 seconds average number of times 120 times]

Receive: 01 10 00 00 00 02 41 C8 [write register response]

- Set online mode [set to 5 seconds 30 times] [[recommended parameters for fast measurement scenarios](#)]

Send: 01 10 00 00 00 02 04 00 05 00 1E 63 A6 [measurement interval 5 seconds average number of times 30 times]

Receive: 01 10 00 00 00 02 41 C8 [write register response]

- Set the handheld mode [[handheld scene recommended working mode](#)]

Send: 0110 00 02 00 02 04 00 3C 00 0A 32 7D [measurement time 60 minutes average number of times 10 times]

Receive: 01 10 00 02 00 02 E0 08 [write register response]

- Set automatic measurement at power-on [[automatically write this parameter to online mode after power-on](#)]

Send: 01 10 00 0C 00 02 04 00 0A 00 78 D3 DA [Measurement interval 10 seconds average number of times 120 times]

Receive: 01 10 00 0C 00 02 81 CB [Write register response]

- Read dissolved oxygen measurement results separately (temperature + dissolved oxygen ratio + dissolved oxygen value + status bit)

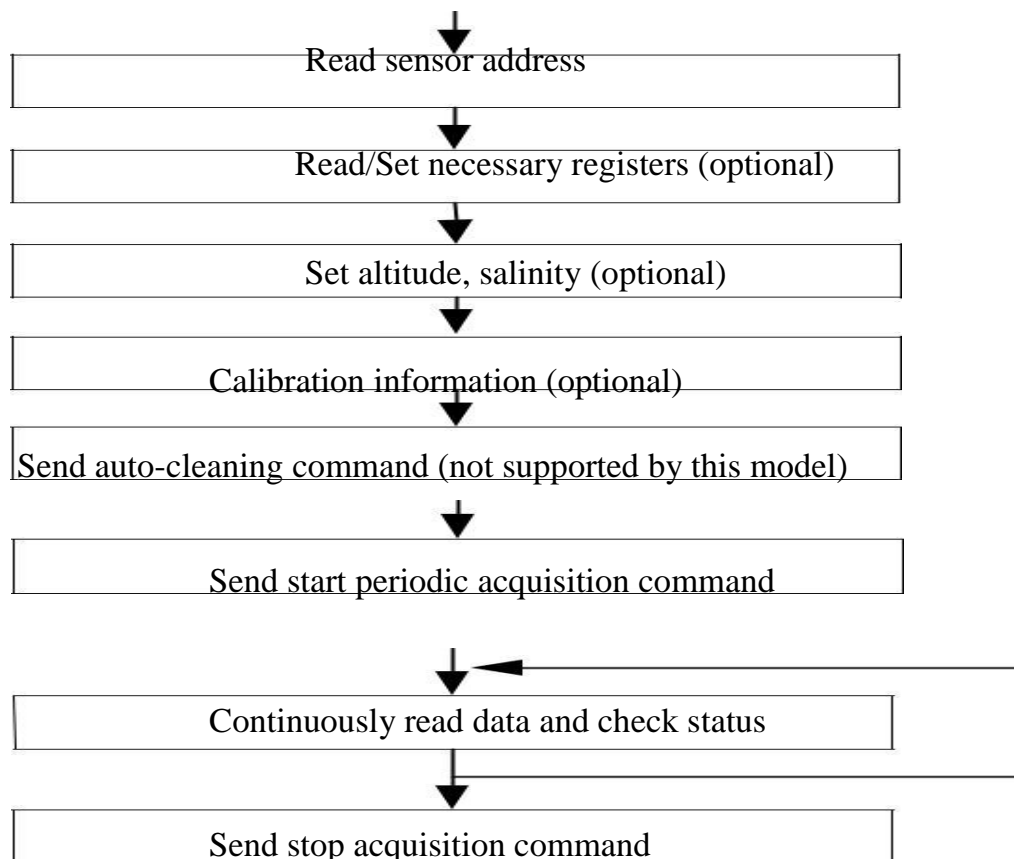
Send: 01 03 00 10 00 08 45 C9

Receive: 01 03 10 1F 4D 0B C5 2B 70 00 00 03 43 00 00 00 00 00 01 1B 2F [int16 temperature 30.13℃ int16 temperature 30.13℃ dissolved oxygen ratio 111.20% dissolved oxygen value 8.35mg/L Countdown 0 status bit 1]

Software Version: Maximum Supported Register Read Count	publish	Registers (original frame)	Frame parsing
230301 The previous value is 38	01 03 00 00 00 26 C4 10 Read 38 messages Memory	01 03 4C 00 0A 00 78 00 00 00 00 64 00 00 00 20 00 00 00 01 00 00 00 01 00 14 00 0A 00 78 00 00 00 1E 36 0A AE 61 A8 00 00 06 5D 00 00 00 00 01 18 07 11 0E 16 05 1B 00 18 07 11 00 00 00 00 20 32 35 39 41 30 50 06 00 3B 00 28 5A D2	01 (Address) 03 (Read) 4C (Byte Count) 00 0A (Time Interval) 00 78 (Averaging Count) 00 00 (Measurement Time) 00 00 (Averaging Count) 00 64 (Altitude) 00 00 (Reserved) 00 20 (Salinity) 00 00 (Reserved) 00 01 (Motor Mode) 00 00 (Motor Cycle) 00 01 (Address) 00 14 (Type) 00 0A (Power-on Auto Time Interval) 00 78 (Power-on Auto Averaging Count) 00 (Calibration Flag) 00 (Zero Oxygen Calibration) 00 (Saturated Oxygen Calibration) 00 (Calibration Countdown) 1E 36 (uint16 Temperature) 0A AE (int16 Temperature) 61 A8 00 00 (Dissolved Oxygen Ratio) 06 5D 00 00 (Dissolved Oxygen Value) 00 00 (Countdown) 00 01 (Flag) 18 07 11 0E (Software Version) 16 05 1B 00 (Hardware Version) 18 07 11 00 (Factory Version) 00 00 (Measurement Duration) 00 00 (Reserved) 20 32 35 39 41 30 50 06 00 3B 00 28 (SN) 5A D2 (CRC)
240401 The previous value is 42	01 03 00 00 00 2A C4 15 Read 42 messages Memory	01 03 54 00 0A 00 78 00 00 00 00 64 00 00 00 20 00 00 00 01 00 00 00 01 00 14 00 0A 00 78 00 00 00 00 1E 36 0A AE 61 A8 00 00 06 5D 00 00 00 00 01 18 07 11 0E 16 05 1B 00 18 07 11 00 00 00 00 20 32 35 39 41 30 50 06 00 3B 00 28 17 D4 00 01 00 00 00 00 85 6E	01 (Address) 03 (Read) 54 (Byte Count) 00 0A (Time Interval) 00 78 (Averaging Count) 00 00 (Measurement Time) 00 00 (Averaging Count) 00 64 (Altitude) 00 00 (Reserved) 00 20 (Salinity) 00 00 (Reserved) 00 01 (Motor Mode) 00 00 (Motor Cycle) 00 01 (Address) 00 14 (Type) 00 0A (Power-on Auto Time Interval) 00 78 (Power-on Auto Averaging Count) 00 (Calibration Flag) 00 (Zero Oxygen Calibration) 00 (Saturated Oxygen Calibration) 00 (Calibration Countdown) 1E 36 (uint16 Temperature) 0A AE (int16 Temperature) 61 A8 00 00 (Dissolved Oxygen Ratio) 06 5D 00 00 (Dissolved Oxygen Value) 00 00 (Countdown) 00 01 (Flag) 18 07 11 0E (Software Version) 16 05 1B 00 (Hardware Version) 18 07 11 00 (Factory Version) 00 00 (Measurement Duration) 00 00 (Reserved) 20 32 35 39 41 30 50 06 00 3B 00 28 (SN) 17 D4 (pH) 00 01 (pH Valid Bit) 00 (pH Calibration Flag) 00 (PH4 Calibration Value) 00 (PH6.86 Calibration Value) 00 (PH9.18 Calibration Value) 85 6E (CRC)
240701 The previous value 44	01 03 00 00 00 2C 44 17 Read 42 messages	01 03 58 00 0A 00 78 00 00 00 00 64 00 00 00 20 00 00 00 01 00 00 00 01 00 14 00 0A 00 78 00 00 00 00 1E 36 0A AE 61 A8 00 00 06 5D 00 00 00 00 01 18 07 11 0E 16 05 1B 00 18 07 11 00 00 00 00 20 32 35 39 41 30 50 06 00 3B 00 28 17 D4 00 01 00 00 00 00 23 45 67 89 69 1D	01 (Address) 03 (Read) 58 (Byte Count) 00 0A (Time Interval) 00 78 (Averaging Count) 00 00 (Measurement Time) 00 00 (Averaging Count) 00 64 (Altitude) 00 00 (Reserved) 00 20 (Salinity) 00 00 (Reserved) 00 01 (Motor Mode) 00 00 (Motor Cycle) 00 01 (Address) 00 14 (Type) 00 0A (Power-on Auto Time Interval) 00 78 (Power-on Auto Averaging Count) 00 (Calibration Flag) 00 (Zero Oxygen Calibration) 00 (Saturated Oxygen Calibration) 00 (Calibration Countdown) 1E 36 (uint16 Temperature) 0A AE (int16 Temperature) 61 A8 00 00 (Dissolved Oxygen Ratio) 06 5D 00 00 (Dissolved Oxygen Value) 00 00 (Countdown) 00 01 (Flag)

	Memory		<p>18 07 11 0E (Software Version) 16 05 1B 00 (Hardware Version) 18 07 11 00 (Factory Version) 00 00 (Measurement Duration) 00 00 (Reserved) 20 32 35 39 41 30 50 06 00 3B 00 28 (SN)</p> <p>17 D4 (pH) 00 01 (pH Valid Bit) 00 (pH Calibration Flag) 00 (PH4 Calibration Value) 00 (PH6.86 Calibration Value) 00 (PH9.18 Calibration Value) 23 45 67 89 (Key) 69 1D (CRC)</p> <p>01 (Address) 03 (Read) 58 (Byte Count) 00 0A (Time Interval) 00 78 (Averaging Count) 00 00 (Measurement Time) 00 00 (Averaging Count) 00 64 (Altitude)</p>
240701 The previous value 52	<p>01 03 00 00</p> <p>00 34 44 1D</p> <p>Read 52 messages Memory</p>	<p>01 03 68 00 0A 00 78 00 00 00 00 00 64 00 00 00 20 00 00 00 01 00 00 00 01 00 14 00 0A 00 78 00 00 00 00</p> <p>1E 36 0A AE 61 A8 00 00 06 5D 00 00 00 00 01 18 07 11 0E 16 05 1B 00 18 07 11 00 00 00 00 00 20 32</p> <p>35 39 41 30 50 06 00 3B 00 28 17 D4 00 01 00 00 00 00 23 45 67 89 00 03 00 00 09 65 00 01 00 00 00 00 00 00 00 12 ED</p>	<p>01 (Address) 03 (Read) 68 (Byte Count) 00 0A (Time Interval) 00 78 (Averaging Count) 00 00 (Measurement Time) 00 00 (Averaging Count) 00 64 (Altitude)</p> <p>00 00 (Reserved) 00 20 (Salinity) 00 00 (Reserved) 00 01 (Motor Mode) 00 00 (Motor Cycle) 00 01 (Address) 00 14 (Type) 00 0A (Power-on Auto Time Interval) 00 78 (Power-on Auto Averaging Count) 00 (Calibration Flag) 00 (Zero Oxygen Calibration) 00 (Saturated Oxygen Calibration) 00 (Calibration Countdown)</p> <p>1E 36 (uint16 Temperature) 0A AE (int16 Temperature) 61 A8 00 00 (Dissolved Oxygen Ratio) 06 5D 00 00 (Dissolved Oxygen Value) 00 00 (Countdown) 00 01 (Flag)</p> <p>18 07 11 0E (Software Version) 16 05 1B 00 (Hardware Version) 18 07 11 00 (Factory Version) 00 00 (Measurement Duration) 00 00 (Reserved) 20 32 35 39 41 30 50 06 00 3B 00 28 (SN)</p> <p>17 D4 (pH) 00 01 (pH Valid Bit) 00 (pH Calibration Flag) 00 (PH4 Calibration Value) 00 (PH6.86 Calibration Value) 00 (PH9.18 Calibration Value) 23 45 67 89 (Key) 00 03 (Fish Pond Mode) 00 00 (Reserved) 09 65 (Batch) 00 01 (Production Serial Number) 00 00 00 00 (Start Working Time) 00 (pH Correction) 00 00 00 (Reserved) 12 ED (CRC)</p>

9. Operation Sequence



- To protect the probe, please send the stop periodic measurement command when not in use.
- Continuously read the measurement value register, **check the data valid bit and status bit**

10. Debugging Tools

For detailed instructions, please refer to the "Dissolved Oxygen Sensor Software Quick Start Guide.pdf".

After the sensor is powered on, connect it to a computer via the RS485 serial port. Once the sensor address is obtained and the measurement parameters are configured, the dissolved oxygen values measured by the sensor can be read.

After the initial measurement is completed, normal data reading begins.

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11. Frequently Asked Questions (FAQ)

- 1) During installation, **the sensor connector terminals must not be immersed in water.**
- 2) For long-term online measurement devices, the sensor needs to be soaked for at least 1 hour during the first use. The measurement data will be more accurate after the fluorescent membrane is fully hydrated.
- 3) In most cases, tap water with aeration for more than 1 hour will have a dissolved oxygen level of about 100%.
- 4) When cleaning manually, use only clean water and rinse gently. Do not scratch the fluorescent membrane with your nails.

12. Dissolved Oxygen Data Knowledge

Dissolved oxygen data represents the amount of oxygen dissolved in water, and it is a core parameter reflecting water quality. It is the most important data in water environment monitoring and aquaculture. Adequate dissolved oxygen in water can fully oxidize and decompose most pollutants, and it can meet the survival needs of cultured animals. High dissolved oxygen is a necessary condition for high-density and healthy aquaculture.

Dissolved oxygen in water is the oxygen from the air that "penetrates" into the water under atmospheric pressure, filling the gaps between water molecules. Therefore, the amount of oxygen that water can hold is directly related to temperature, atmospheric pressure (altitude), and salinity. In the DO-Sx sensor, the dissolved oxygen concentration percentage (%) can be read, and the value can be converted into mg/L (conversion formulas are provided in Appendix 1). The value in mg/L can also be directly read from the sensor. When reading the value in mg/L directly from the probe, altitude and salinity data must be pre-configured through the RS485 interface. By default, both altitude and salinity are set to 0.

In general, in freshwater at low altitudes, temperature has the greatest effect on dissolved oxygen in water. The higher the temperature, the lower the dissolved oxygen concentration, and the lower the temperature, the higher the dissolved oxygen concentration. **For specific values, please refer to Appendix 2 for reference.**

13. Dissolved Oxygen Data and Aquaculture

- In natural water bodies, the dissolved oxygen concentration in the upper layers is much higher than in the lower layers. Therefore, dissolved oxygen values measured within a depth of **0.3m** cannot fully reflect the dissolved oxygen levels of the entire pond. It is necessary to maintain a certain water flow to ensure adequate dissolved oxygen, and water wheels or oxygenation equipment must remain continuously operational.
- In summer, when the temperature is high and atmospheric pressure is low (on cloudy days), the water's dissolved oxygen capacity is lower, and it depletes quickly, requiring slow replenishment. **It is recommended not to wait until the dissolved oxygen is very low before turning on the oxygenation equipment.**
- In high-density aquaculture in deep ponds, attention should be paid to the dissolved oxygen levels in the deeper water layers. It is recommended to use multiple probes for measurement to assess dissolved oxygen at different depths. One probe should measure the surface water dissolved oxygen within 1 meter, while another probe should measure below 2-3 meters to obtain accurate dissolved oxygen levels. When the dissolved oxygen at the bottom fails to meet the requirements, devices such as bottom aerators, paddle-wheel aerators with water circulation functions, or down-flow aeration boats can be used to increase the oxygen content at the bottom.
- High dissolved oxygen levels throughout the entire pond can bring many benefits, including improved pond bottom conditions, reduced diseases, and enhanced vitality. Proper dissolved oxygen management is a necessary condition for successful aquaculture.
- Under normal circumstances, it is recommended to turn on the oxygenation equipment when low dissolved oxygen is detected at night, regardless of the dissolved oxygen value. The equipment should only be turned off when the sun rises and the temperature increases the following day.
- Different aquatic species, such as fish, shrimp, and crabs, have varying dissolved oxygen requirements. Maintaining reasonable dissolved oxygen levels throughout the pond, including at the bottom, can prevent issues such as surface fish, sudden death, and poor molting.

Note: This section provides only basic knowledge. For more information on dissolved oxygen and aquaculture, please refer to relevant resources.

14. Appendix 1: Algorithm for Converting Dissolved Oxygen % to mg/L

Calculate DO (mg/L), i.e., convert DO (%) to DO (mg/L) using the formula:

$$\text{DO(mg/L)} = \text{DO(\%)} * X1 * X2 * 1.4276 \text{ (Note: 1 ml/L = 1.4276 mg/L)}$$

$$\ln X1 = A1 + A2 \cdot 100/T + A3 \cdot \ln T/100 + A4 \cdot T/100 + S * [B1 + B2 \cdot T/100 + B3 \cdot (T/100)^2]$$

$$A1 = -173.4292$$

$$B1 = -0.033096,$$

$$A2 = 249.6339$$

$$B2 = 0.014259,$$

$$A3 = 143.3483$$

$$B3 = -0.001700;$$

$$A4 = -21.8492$$

$$T = 273.15 + t \text{ (T is the absolute temperature, t is the temperature in Celsius)}$$

$$X2 = (\text{Phmg} - u) / (760 - u)$$

$$\text{Phmg} = \text{pressure} * 760 / 101.325$$

(pressure is the atmospheric pressure value, in kPa)

$$\text{Logu} = 8.10765 - (1750.286 / (235 + t))$$

(t is the temperature in Celsius)

```
//*****  
*****
```

```
/* Below is the reference C code */
```

```
#include <math.h>
```

```
float pressure = 101.325; // Standard atmospheric pressure (fill in according to  
actual conditions)
```

```
float Phmg = 0.0;
```

```
float t = 25.0; // Temperature in Celsius (fill in according to actual conditions)
```

```
float T = 0.0;
```

```
float S = 0.0; // Salinity, fill in according to actual conditions
```

```
T = 273.15 + t; // t is the current temperature in Celsius
```

```
X1' = -173.4292 // X1' = ln X1, according to the classical formula above
```

```
+ 249.6339 * (100 / T)
```

```
+ 143.3483 * log(T / 100) // log() function is ln(x)
```

```
+ -21.8492 * (T / 100)
```

```
+ S * (-0.033096 + (0.014259 * T) / 100
```

```
- 0.001700 * (T / 100) * (T / 100));
```

```
X1 = exp(X1'); // Natural logarithm, X1 = exp(X1')
```

```
u' = 8.10765 - (1750.286 / (235 + t)); // u' = log u
```

```
u = pow(10, u'); // u = 10^u'
```

```
Phmg = pressure * 760 / 101.325; // Calculate Phmg
```

$X2 = ((Phmg - u) / (760 - u)); // \text{Calculate } X2$

$DO(mg/L) = DO(\%) * X1 * X2 * 1.4276; // \text{Convert } DO(\%) \text{ to } DO(mg/L)$

//*****

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Left column: Temperature (unit: °C) Top row: Dissolved Oxygen Percentage (unit: %) Middle: Milligram value (unit: mg/L) [Altitude: 0 | Salinity: 0]

0	0.00	1.46	2.92	4.38	5.83	7.29	8.75	10.21	11.67	13.13	14.59	16.05	17.50	18.96	20.42	21.88	23.34	24.80	26.26	27.72	29.17
1	0.00	1.42	2.84	4.26	5.67	7.09	8.51	9.93	11.35	12.77	14.18	15.60	17.02	18.44	19.86	21.28	22.69	24.11	25.53	26.95	28.37
2	0.00	1.38	2.76	4.14	5.52	6.90	8.28	9.66	11.04	12.42	13.80	15.18	16.56	17.94	19.32	20.70	22.08	23.46	24.84	26.22	27.60
3	0.00	1.34	2.69	4.03	5.37	6.72	8.06	9.40	10.75	12.09	13.43	14.78	16.12	17.46	18.80	20.15	21.49	22.83	24.18	25.52	26.86
4	0.00	1.31	2.62	3.92	5.23	6.54	7.85	9.16	10.46	11.77	13.08	14.39	15.70	17.00	18.31	19.62	20.93	22.24	23.55	24.85	26.16
5	0.00	1.27	2.55	3.82	5.10	6.37	7.65	8.92	10.20	11.47	12.74	14.02	15.29	16.57	17.84	19.12	20.39	21.67	22.94	24.21	25.49
6	0.00	1.24	2.48	3.73	4.97	6.21	7.45	8.70	9.94	11.18	12.42	13.67	14.91	16.15	17.39	18.63	19.88	21.12	22.36	23.60	24.85
7	0.00	1.21	2.42	3.63	4.85	6.06	7.27	8.48	9.69	10.90	12.12	13.33	14.54	15.75	16.96	18.17	19.38	20.60	21.81	23.02	24.23
8	0.00	1.18	2.36	3.55	4.73	5.91	7.09	8.27	9.46	10.64	11.82	13.00	14.18	15.37	16.55	17.73	18.91	20.09	21.28	22.46	23.64
9	0.00	1.15	2.31	3.46	4.61	5.77	6.92	8.08	9.23	10.38	11.54	12.69	13.84	15.00	16.15	17.31	18.46	19.61	20.77	21.92	23.07
10	0.00	1.13	2.25	3.38	4.51	5.63	6.76	7.89	9.01	10.14	11.27	12.39	13.52	14.65	15.77	16.90	18.03	19.15	20.28	21.41	22.53
11	0.00	1.10	2.20	3.30	4.40	5.50	6.60	7.70	8.80	9.90	11.01	12.11	13.21	14.31	15.41	16.51	17.61	18.71	19.81	20.91	22.01
12	0.00	1.08	2.15	3.23	4.30	5.38	6.45	7.53	8.60	9.68	10.76	11.83	12.91	13.98	15.06	16.13	17.21	18.28	19.36	20.43	21.51
13	0.00	1.05	2.10	3.15	4.21	5.26	6.31	7.36	8.41	9.46	10.51	11.57	12.62	13.67	14.72	15.77	16.82	17.88	18.93	19.98	21.03
14	0.00	1.03	2.06	3.09	4.11	5.14	6.17	7.20	8.23	9.26	10.28	11.31	12.34	13.37	14.40	15.43	16.45	17.48	18.51	19.54	20.57
15	0.00	1.01	2.01	3.02	4.02	5.03	6.04	7.04	8.05	9.06	10.06	11.07	12.07	13.08	14.09	15.09	16.10	17.10	18.11	19.12	20.12
16	0.00	0.98	1.97	2.95	3.94	4.92	5.91	6.89	7.88	8.86	9.85	10.83	11.82	12.80	13.79	14.77	15.76	16.74	17.73	18.71	19.70
17	0.00	0.96	1.93	2.89	3.86	4.82	5.79	6.75	7.71	8.68	9.64	10.61	11.57	12.53	13.50	14.46	15.43	16.39	17.36	18.32	19.28
18	0.00	0.94	1.89	2.83	3.78	4.72	5.67	6.61	7.55	8.50	9.44	10.39	11.33	12.28	13.22	14.16	15.11	16.05	17.00	17.94	18.89
19	0.00	0.93	1.85	2.78	3.70	4.63	5.55	6.48	7.40	8.33	9.25	10.18	11.10	12.03	12.95	13.88	14.80	15.73	16.65	17.58	18.50
20	0.00	0.91	1.81	2.72	3.63	4.53	5.44	6.35	7.25	8.16	9.07	9.97	10.88	11.79	12.69	13.60	14.51	15.41	16.32	17.23	18.13
21	0.00	0.89	1.78	2.67	3.56	4.44	5.33	6.22	7.11	8.00	8.89	9.78	10.67	11.56	12.45	13.33	14.22	15.11	16.00	16.89	17.78
22	0.00	0.87	1.74	2.62	3.49	4.36	5.23	6.10	6.97	7.85	8.72	9.59	10.46	11.33	12.20	13.08	13.95	14.82	15.69	16.56	17.44
23	0.00	0.86	1.71	2.57	3.42	4.28	5.13	5.99	6.84	7.70	8.55	9.41	10.26	11.12	11.97	12.83	13.68	14.54	15.39	16.25	17.10
24	0.00	0.84	1.68	2.52	3.36	4.20	5.03	5.87	6.71	7.55	8.39	9.23	10.07	10.91	11.75	12.59	13.43	14.26	15.10	15.94	16.78
25	0.00	0.82	1.65	2.47	3.29	4.12	4.94	5.77	6.59	7.41	8.24	9.06	9.88	10.71	11.53	12.35	13.18	14.00	14.82	15.65	16.47
26	0.00	0.81	1.62	2.43	3.23	4.04	4.85	5.66	6.47	7.28	8.09	8.89	9.70	10.51	11.32	12.13	12.94	13.75	14.55	15.36	16.17
27	0.00	0.79	1.59	2.38	3.18	3.97	4.76	5.56	6.35	7.15	7.94	8.73	9.53	10.32	11.12	11.91	12.71	13.50	14.29	15.09	15.88
28	0.00	0.78	1.56	2.34	3.12	3.90	4.68	5.46	6.24	7.02	7.80	8.58	9.36	10.14	10.92	11.70	12.48	13.26	14.04	14.82	15.60
29	0.00	0.77	1.53	2.30	3.07	3.83	4.60	5.36	6.13	6.90	7.66	8.43	9.20	9.96	10.73	11.50	12.26	13.03	13.79	14.56	15.33
30	0.00	0.75	1.51	2.26	3.01	3.77	4.52	5.27	6.03	6.78	7.53	8.28	9.04	9.79	10.54	11.30	12.05	12.80	13.56	14.31	15.06
31	0.00	0.74	1.48	2.22	2.96	3.70	4.44	5.18	5.92	6.66	7.40	8.14	8.88	9.62	10.37	11.11	11.85	12.59	13.33	14.07	14.81
32	0.00	0.73	1.46	2.18	2.91	3.64	4.37	5.10	5.82	6.55	7.28	8.01	8.74	9.46	10.19	10.92	11.65	12.37	13.10	13.83	14.56
33	0.00	0.72	1.43	2.15	2.86	3.58	4.30	5.01	5.73	6.44	7.16	7.87	8.59	9.31	10.02	10.74	11.45	12.17	12.89	13.60	14.32
34	0.00	0.70	1.41	2.11	2.82	3.52	4.22	4.93	5.63	6.34	7.04	7.75	8.45	9.15	9.86	10.56	11.27	11.97	12.67	13.38	14.08
35	0.00	0.69	1.39	2.08	2.77	3.46	4.16	4.85	5.54	6.24	6.93	7.62	8.31	9.01	9.70	10.39	11.08	11.78	12.47	13.16	13.86
36	0.00	0.68	1.36	2.05	2.73	3.41	4.09	4.77	5.45	6.14	6.82	7.50	8.18	8.86	9.54	10.23	10.91	11.59	12.27	12.95	13.63
37	0.00	0.67	1.34	2.01	2.68	3.35	4.03	4.70	5.37	6.04	6.71	7.38	8.05	8.72	9.39	10.06	10.74	11.41	12.08	12.75	13.42
38	0.00	0.66	1.32	1.98	2.64	3.30	3.96	4.62	5.28	5.94	6.60	7.27	7.93	8.59	9.25	9.91	10.57	11.23	11.89	12.55	13.21
39	0.00	0.65	1.30	1.95	2.60	3.25	3.90	4.55	5.20	5.85	6.50	7.15	7.80	8.45	9.10	9.75	10.40	11.06	11.71	12.36	13.01
40	0.00	0.64	1.28	1.92	2.56	3.20	3.84	4.48	5.12	5.76	6.40	7.04	7.68	8.32	8.97	9.61	10.25	10.89	11.53	12.17	12.81