

PWL-U80 Underwater Ultrasonic Distance Sensor

Instruction Manual

I. Measurement Principle

Ultrasonic waves are emitted from the sensor surface. During propagation, these waves are reflected when they encounter interfaces between different media or obstacles within the same medium, and are then received by the sensor.

The circuit knows both the time of emission and the time of reception.

The distance to the interface or obstacle is calculated as follows:

The unit of distance is meters (m);

the unit of sound speed is meters per second (m/s);

the unit of propagation time is seconds (s).

Because the speed of sound in liquids or solids is directly related to temperature, temperature compensation is required in specific environments to determine the exact speed of sound in meters per second based on the temperature.

II. Usage Environment

1. Liquids:

The sensor is available in three housing materials: ABS, SUS304, and SS316 stainless steel.

The liquid must be non-corrosive to these three housing materials and must be able to effectively conduct ultrasonic waves.

Liquids unsuitable for ultrasonic wave conduction include:

- ① Liquids with an air bubble content exceeding 0.1%;
- ② Liquids with a solid particulate matter content exceeding 0.1%;
- ③ Liquids with a suspended solids content exceeding 1%.

The above list of "unsuitable liquids for ultrasonic wave conduction" applies only to this product. Replacing the sensor with a larger-sized ultrasonic underwater distance sensor will allow measurements in liquids with slightly higher concentrations of air bubbles, solid particulate matter, and suspended solids.

2. Solids:

The solid must be non-corrosive to these three shell materials and be able to effectively conduct ultrasonic waves. It must also be dense and free of air bubbles.

Unsuitable solids for ultrasonic wave conduction:

- ① Solids containing air bubbles;
- ② Solids containing solid particles or fibers;
- ③ Solids with linings or interlayers.

The sensor cannot properly measure the internal liquid level through the following solids.
For example: fiberglass, PE, enamel, metal cans with rubber linings, metal cans with anti-corrosion coatings, metal cans with PTFE linings, metal cans with wear-resistant linings, etc.

III. Technical Parameters

General parameters				
Transducer frequency	300KHz	200KHz	200KHz	88KHz
Measurement range	50m	100m	200m	300m
Blind area	0.50m	0.70m	0.85m	1.00m
Transmission angle	5.7°±0.6°	8.7°±0.9°	8.7°±0.9°	16.5°±1.7°
Fastest response time for active upload	250ms/time	290ms/time	590ms/time	900ms/time
Weight (Direct cable output)	≈542g (with 5m cable)	≈576g (with 5m cable)	≈576g (with 5m cable)	≈710g (with 5m cable)
Electrical characteristics				
Operating voltage	10.8～26.4V, reverse polarity protection.			
No-load current	≤15mA			
Voltage drop	≤1.5V			
Startup delay	<2000ms (Software delay is protected; final version pending)			
Output characteristics				
Output type	Standard RS485 output (Modbus-RTU protocol)			
Rated operating current	≤100mA, short circuit/overload protection			
Repeatability accuracy	±0.25% (standard test tank)			
On-site accuracy	2cm±0.5%D (D refers to the measured depth), Note: The measurement accuracy of samples sent to a third-party testing institution is 2cm±0.1D.			
Ambient temperature				
Operating temperature	-20～+60℃;			
Storage temperature	-20～+60℃;			
Mechanical properties				
Output connection method	4-core cable/aviation plug cable			
Cable length	The default length is 5 meters (other lengths require customization).			
Aircraft insert weight	88KHz: 630g; 200KHz: 477g; 300KHz: 440g;			
Accessory weight	3 washers + 1 ABS nut, total weight 93g			
Protection level	IP68 at a depth of 100 meters			
Housing material	ABS(only for 50m, 100, 200m), SUS304, SUS316			

Note:

After the communication protocol is set to active upload, the "fastest response time" specified for each measurement within the maximum measurement range does not mean that every measurement will take exactly this time.

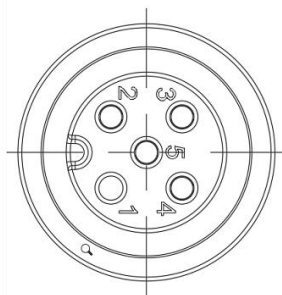
For example: if the measurement range is 100 meters and the fastest response time is 290ms/measurement, it does not mean that every measurement of 100 meters will take exactly 290ms.

IV. Installation Instructions

1. Electrical wiring diagram (if there are specific markings on the wires, follow the markings).

Red wire — Power supply + White wire (blue wire) — 485A/TTL (RXD)
 Black wire — Power supply Yellow line (yellow-green line) — 485B/TTL (TXD)

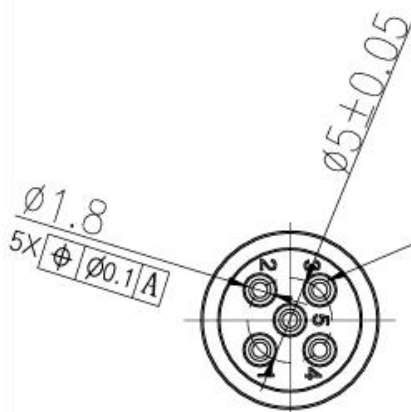
2. Aircraft plug head wiring sequence



Wiring sequence:

- 1: Red
- 2: Blue
- 3: Black
- 4: Yellow
- 5: With pins, do not connect.

3. Male connector wire sequence



Wiring sequence:

- 1: Red
- 2: Blue
- 3: Black
- 4: Yellow
- 5: With pins, do not connect.

V. Product Images

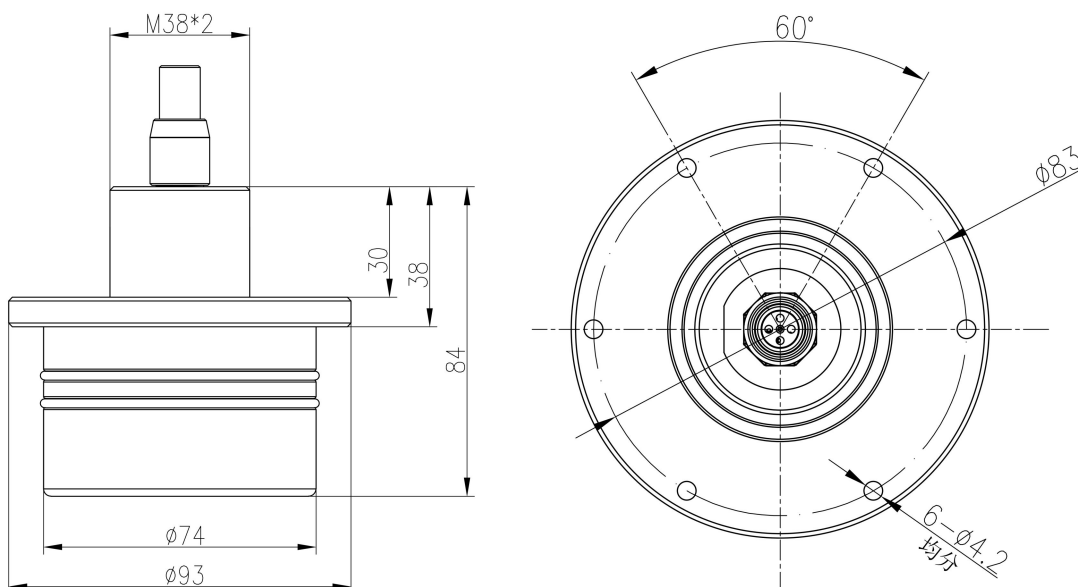
1. Actual product image - ABS shell



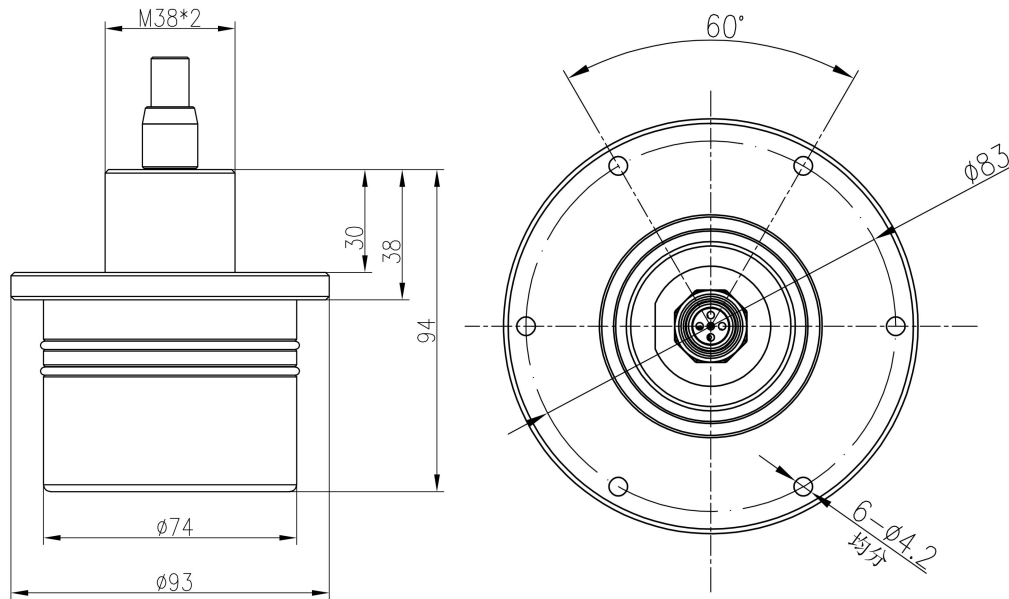
2. Actual product image - stainless steel casing



3. Shell Dimensions - Measurement Range 50m, 100m, 200m



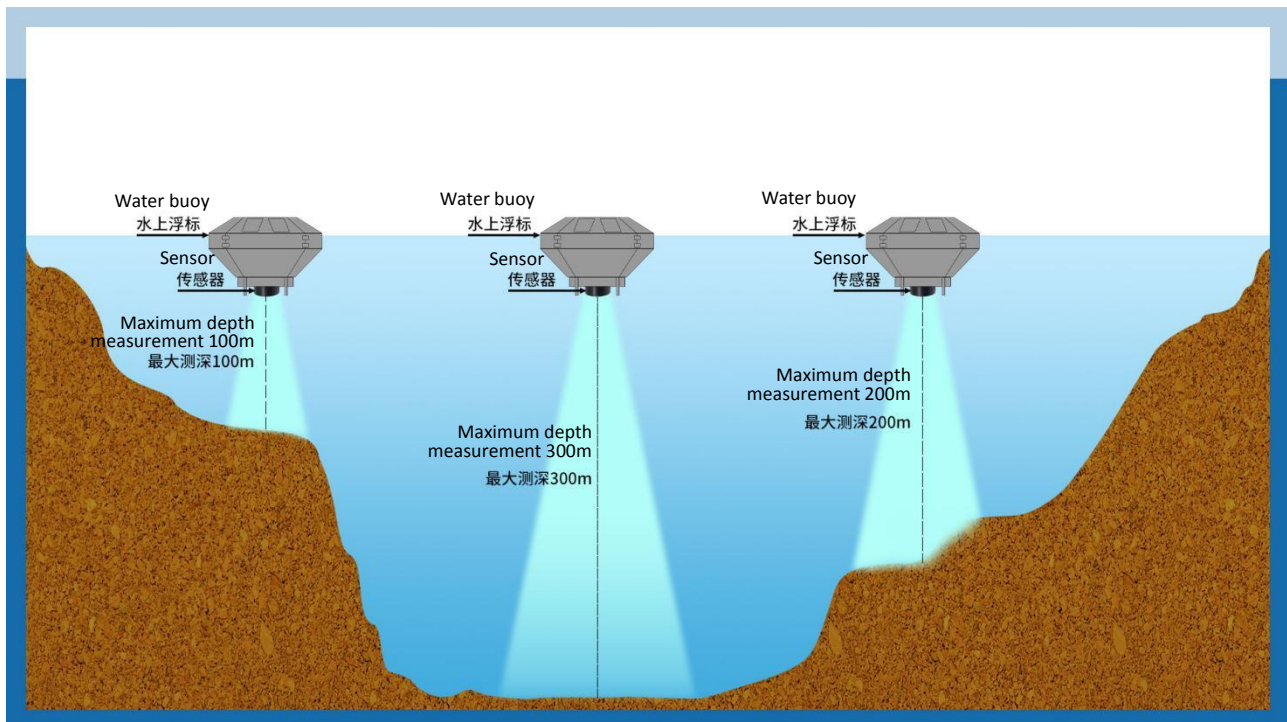
4. Shell Dimensions - Measurement Range 300 meters



VI. Scope of Application

1. Using a buoy to measure water depth

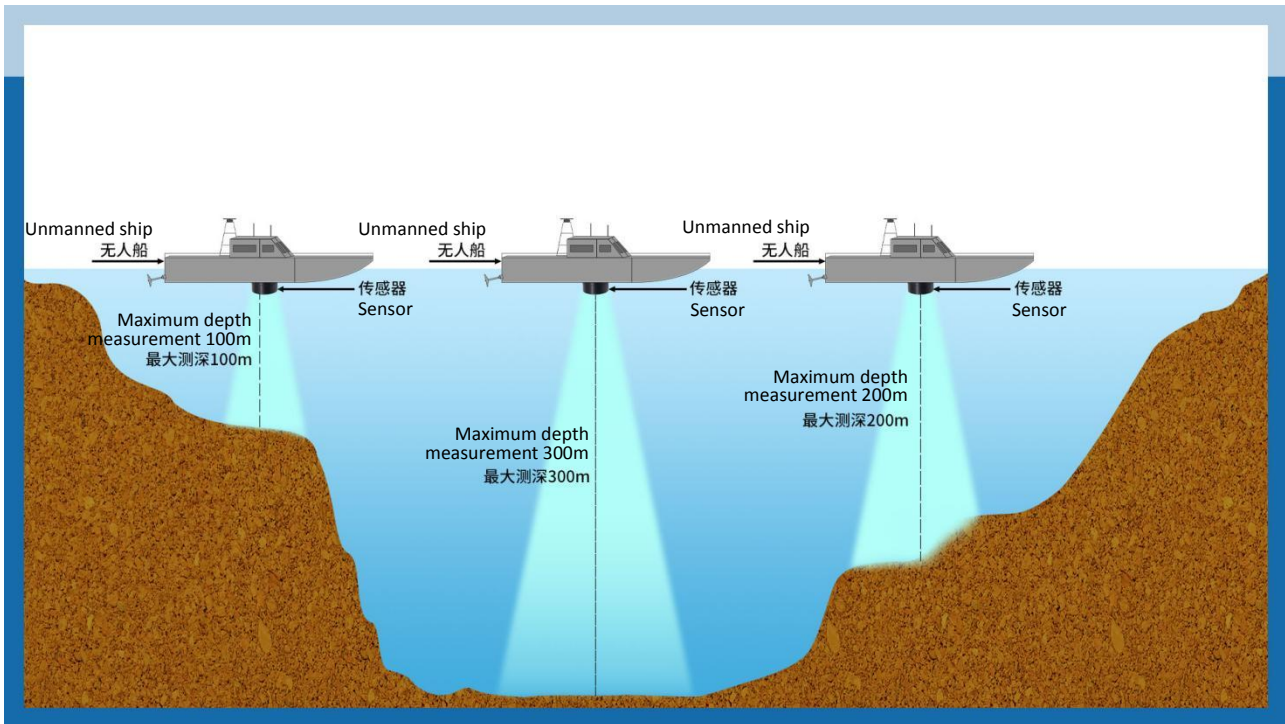
PWL-U80 comes in four measuring ranges: 50 meters, 100 meters, 200 meters, and 300 meters. The model with the 50-meter measuring range is not shown in the image below.



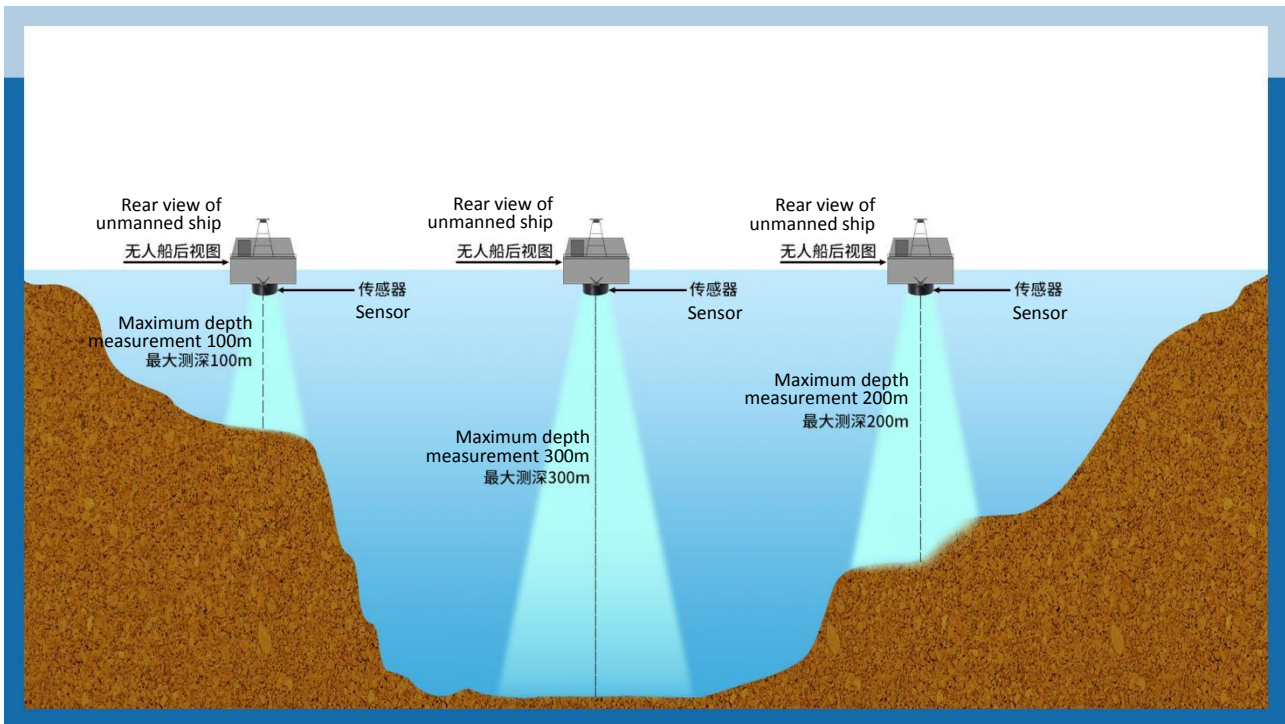
2. Unmanned surface vessel equipped with depth sounding

PWL-U80 comes in four measurement ranges: 50 meters, 100 meters, 200 meters, and 300 meters. The 50-meter model is not shown in the image below.

When installed on an unmanned surface vessel, it is necessary to avoid the area affected by water jets from the propeller or thruster.



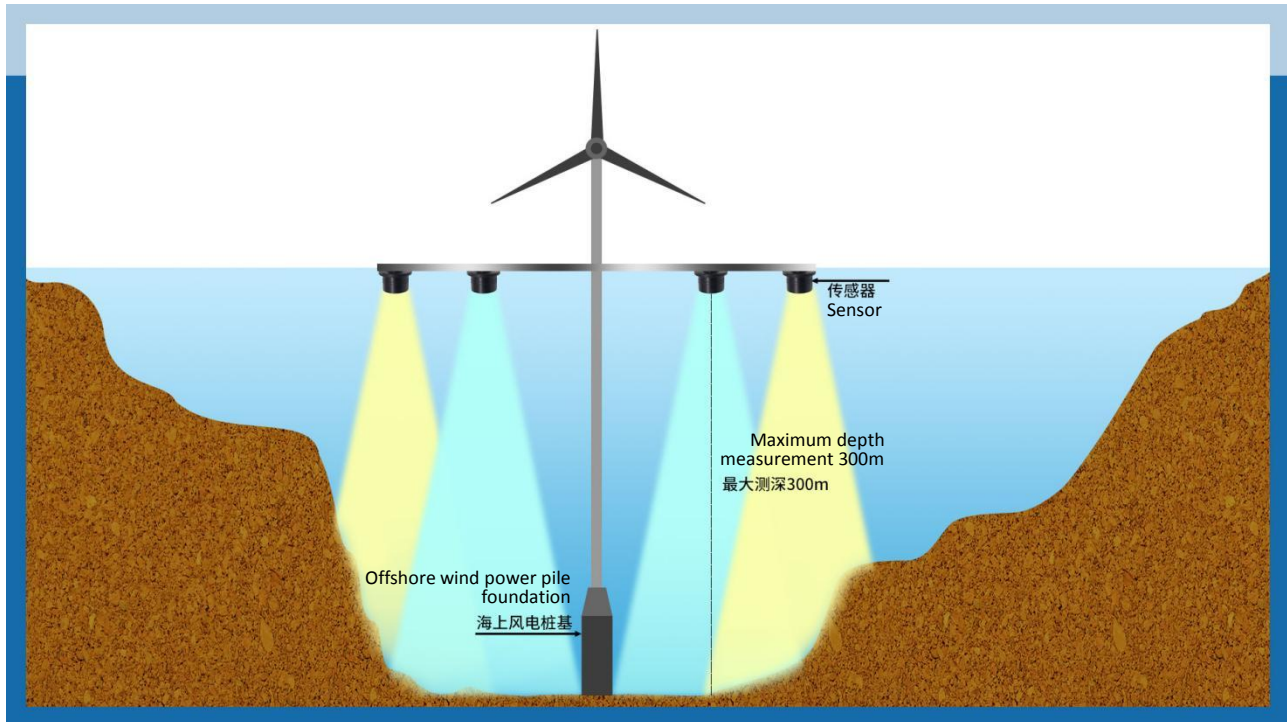
The image below shows a rear view of the PWL-U80 mounted on an unmanned vessel.



3. Offshore wind turbine pile foundation scour detection

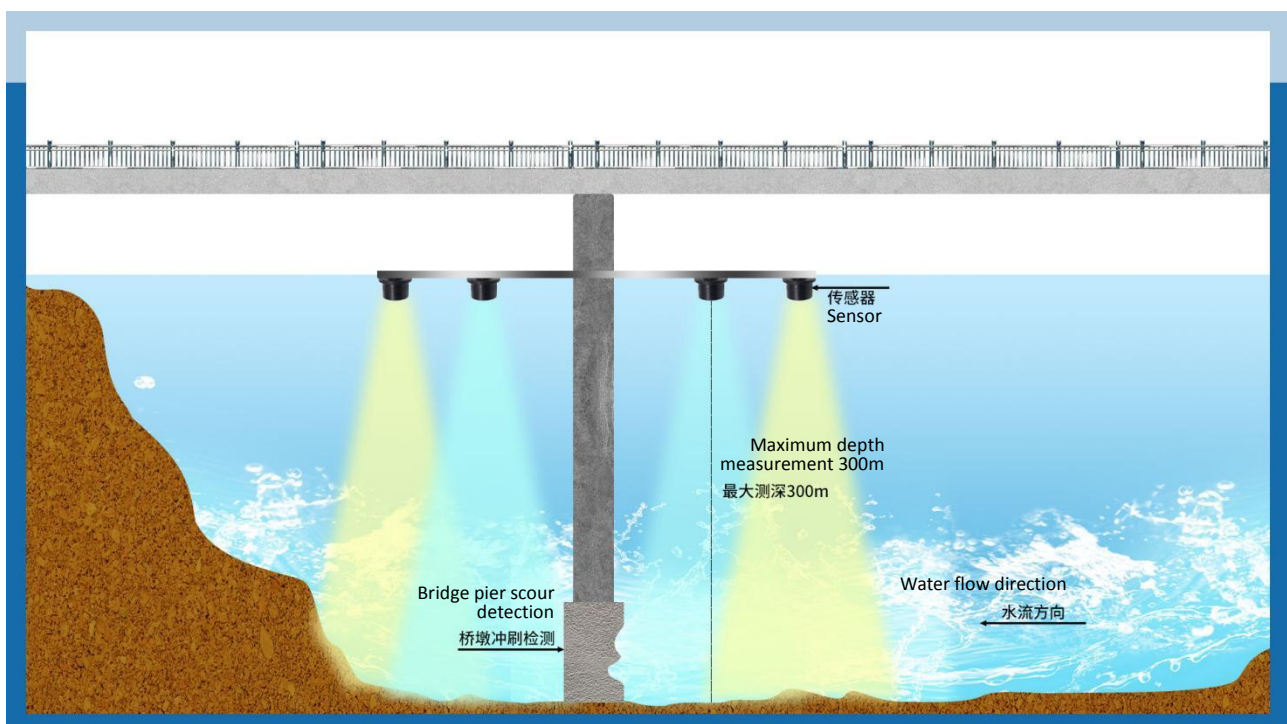
To detect seawater erosion around offshore wind turbine foundations, two PWL-U80 depth sounders should be installed in each of the four cardinal directions (north, south, east, and

west) of the offshore wind turbine foundation. The extent of seawater erosion can be determined by measuring the depth changes of the two measuring surfaces in each direction of the offshore wind turbine foundation.

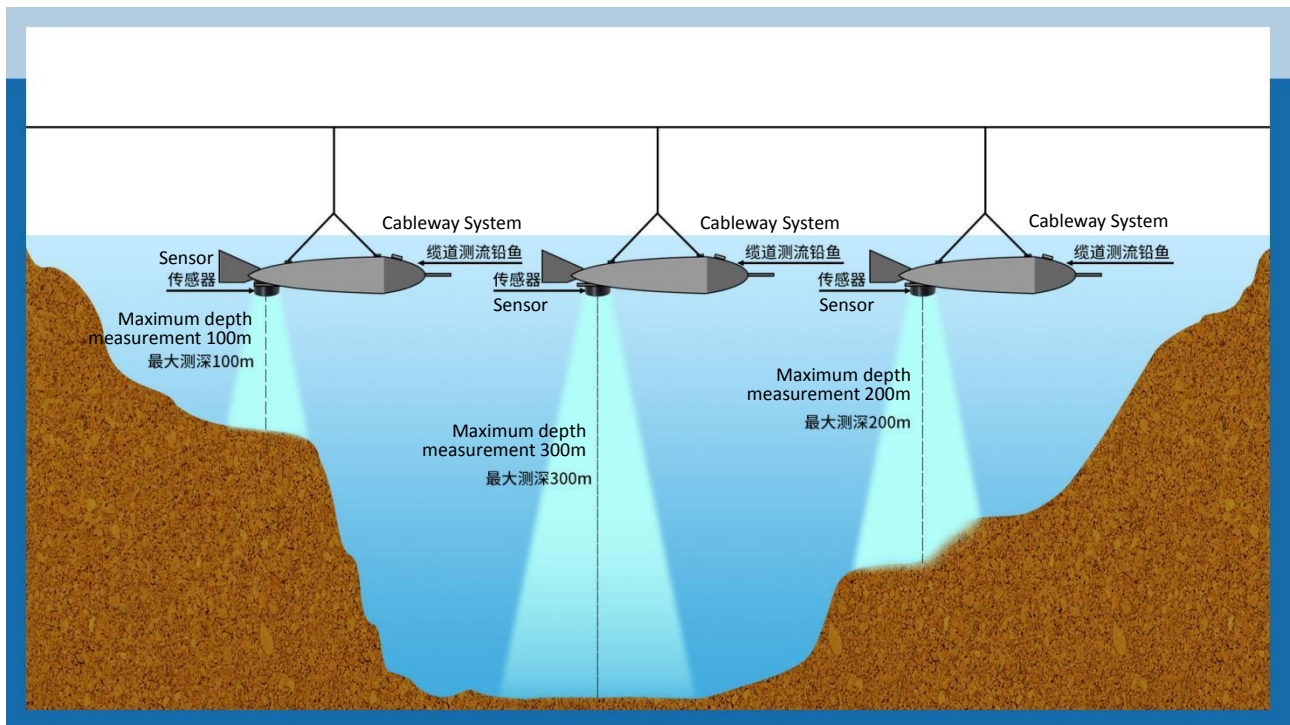


4. Bridge pier scour detection

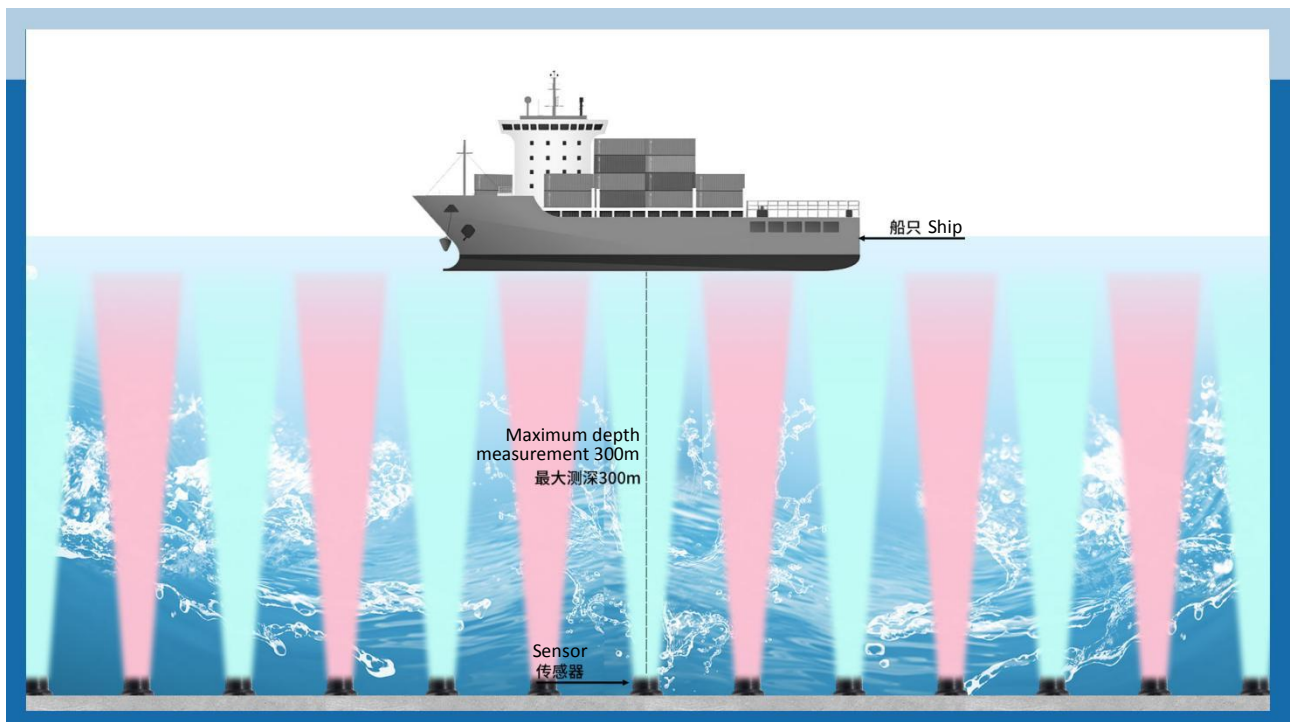
To detect the erosion of the riverbed around the bridge pier, two PWL-U80 depth sounders should be installed in each of the four directions (front, back, left, and right) facing the bridge pier towards the water flow. By measuring the depth changes of the two measuring surfaces in each direction, the extent of erosion of the riverbed near the bridge pier can be determined.

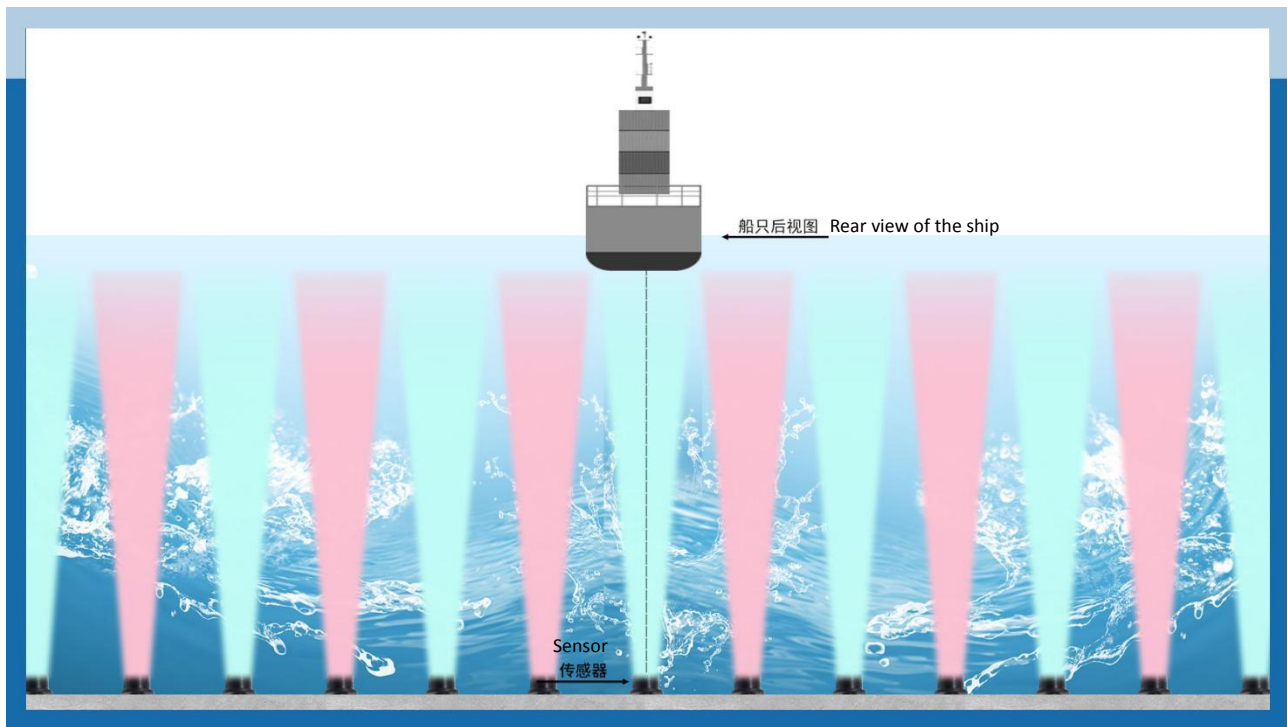


5. Cableway System top depth

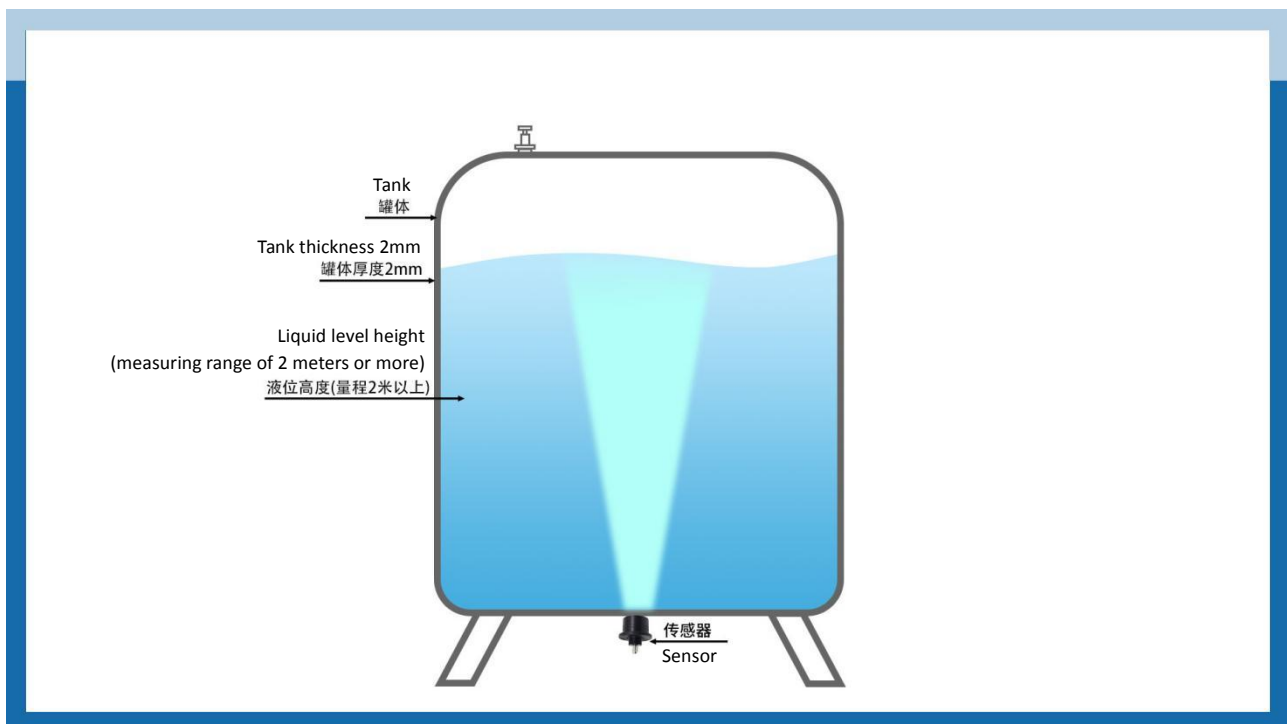


6. Ship draft detection

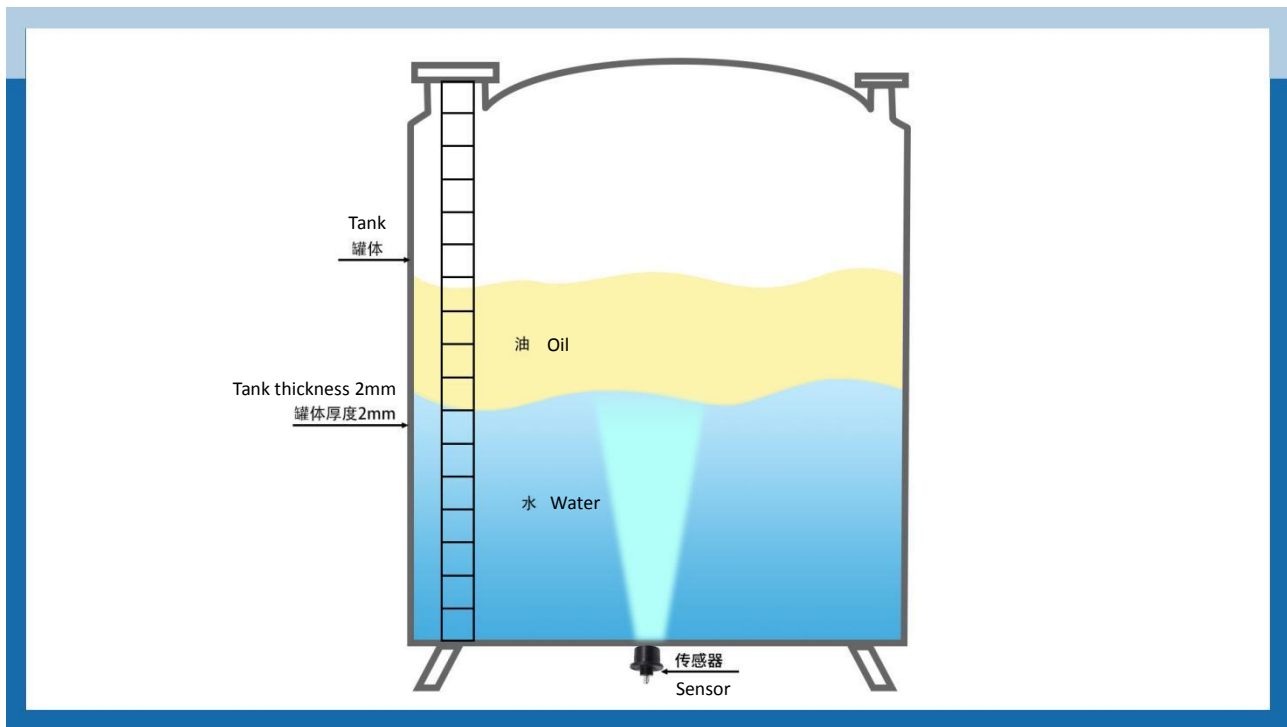




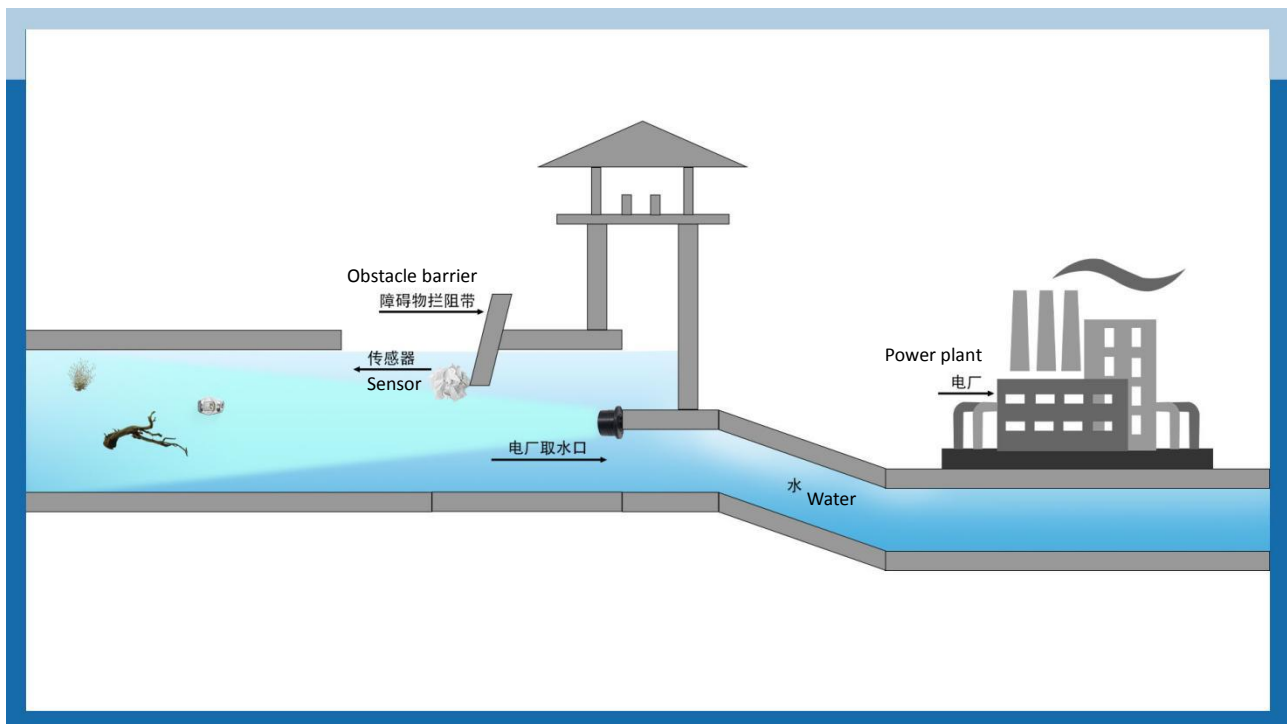
7. Measuring the liquid level inside the tank through a steel plate (measuring range of 2 meters or more).



8. Measurement of water level at the bottom of crude oil tank



9. Power plant water intake obstruction detection

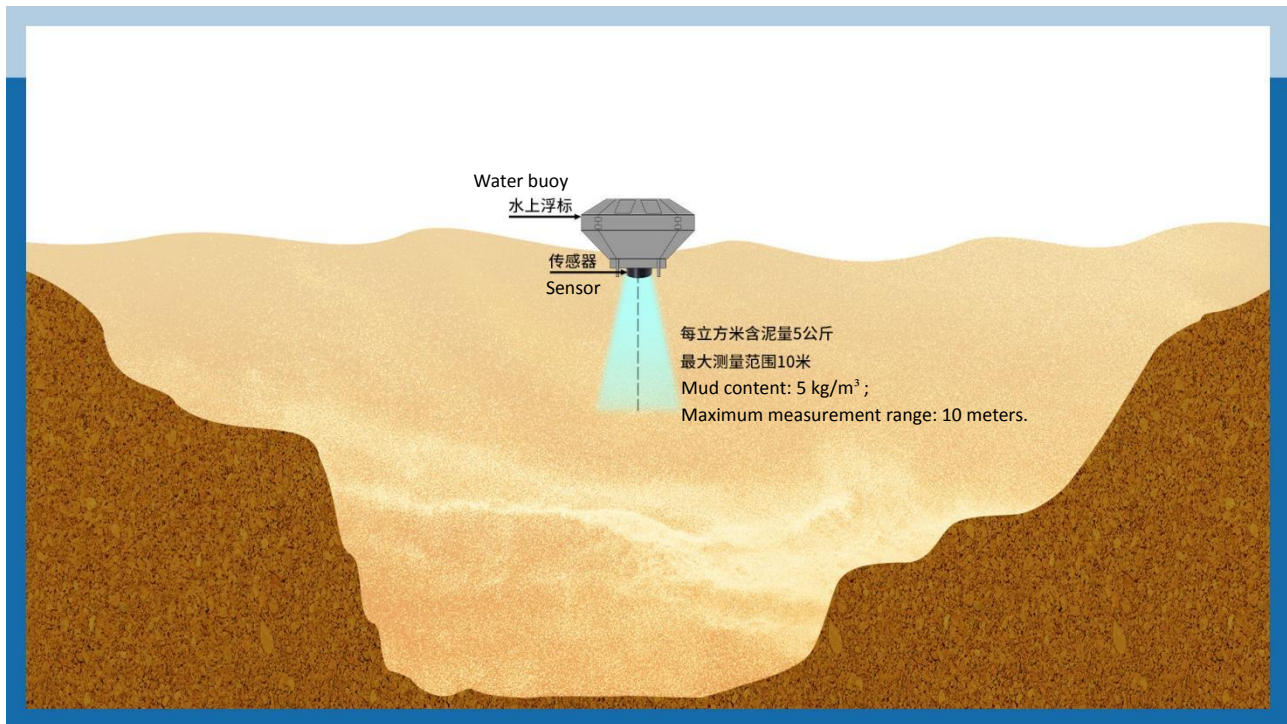


10. Depth measurement in water with high mud content

The **mud** and **sand** content in water **causes varying degrees of attenuation** in ultrasonic waves during transmission, ultimately reducing the sensor's maximum measurement range. Here, mud refers to powdery solids similar to flour, and sand refers to solid particles at least the same size as or larger than ordinary yellow sand.

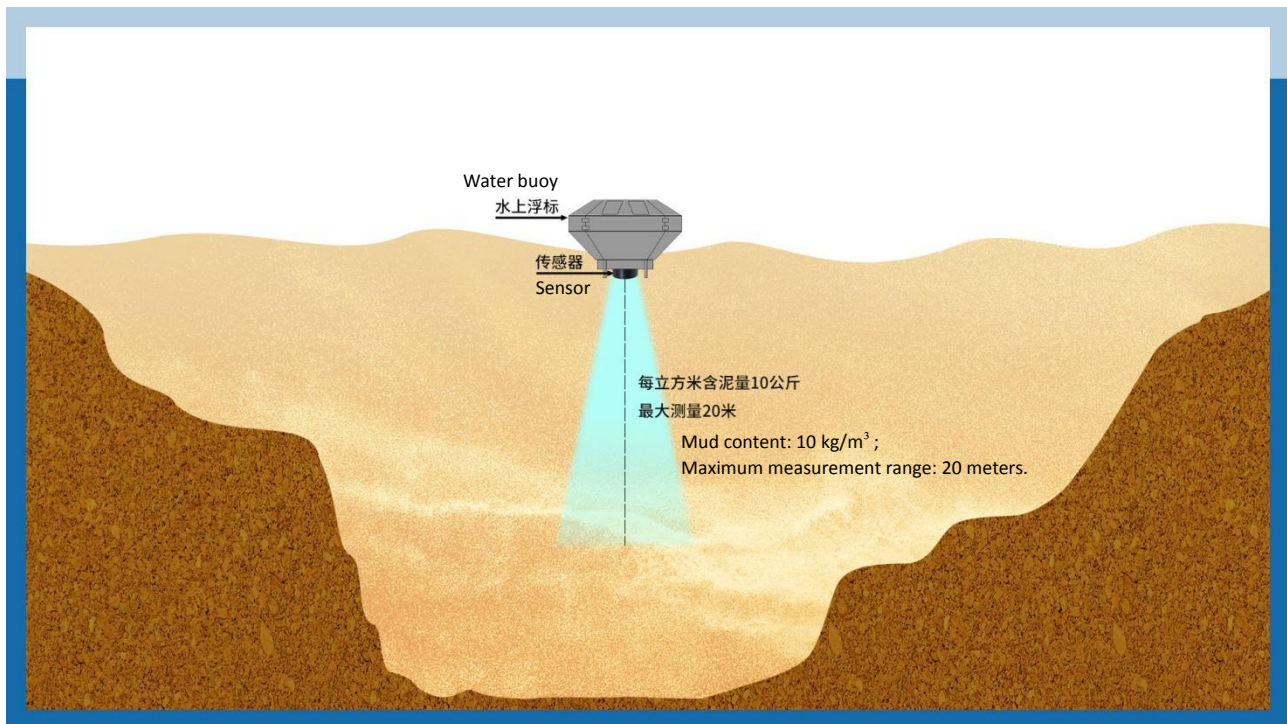
The PWL-U80, with a maximum measurement range of 100 meters, has a maximum measurement range of approximately 10 meters under conditions of 5 kg of mud per cubic

meter. Note: The mud mentioned here refers to powdery solids similar to flour, not granular solids.



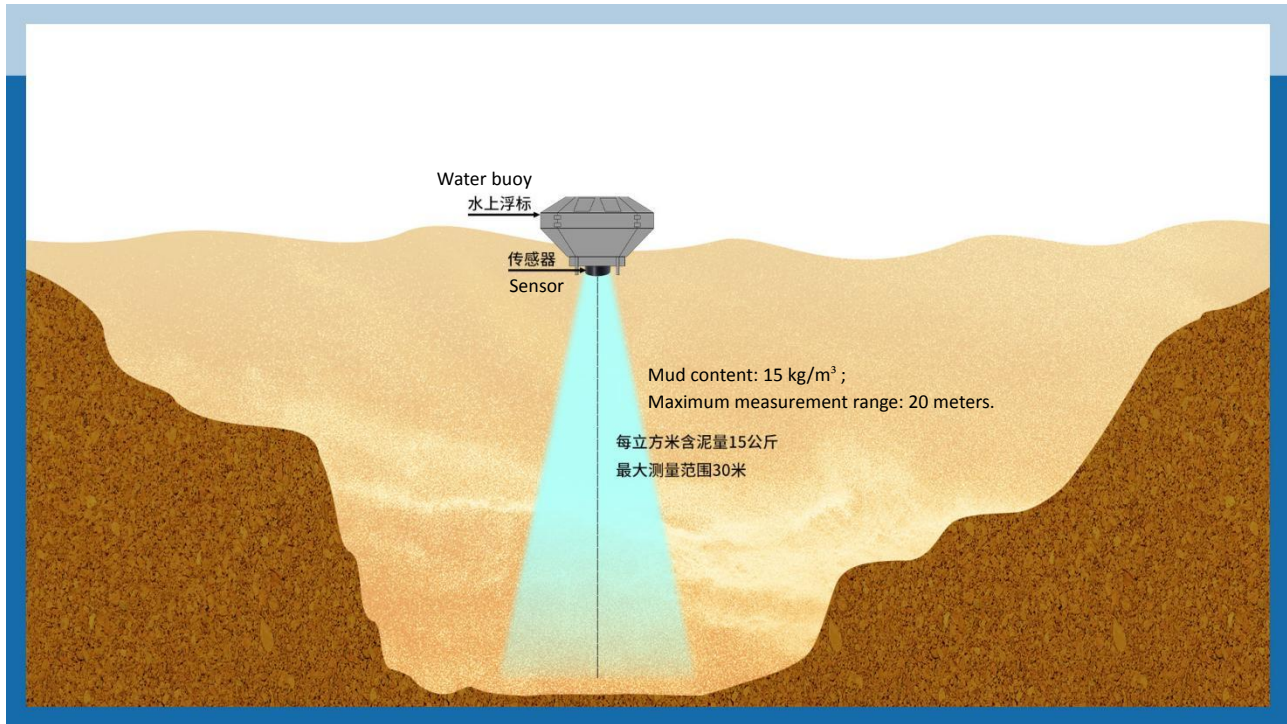
The PWL-U80 has a maximum measuring range of 200 meters. However, under conditions of 10 kg of mud per cubic meter, the maximum measuring range is approximately 20 meters.

Note: The mud mentioned here refers to a powdery solid similar to flour, not a granular solid.



The PWL-U80 has a maximum measuring range of 300 meters. However, under conditions of 15 kg of mud per cubic meter, the maximum measuring range is approximately 30 meters.

Note: The mud mentioned here refers to a powdery solid similar to flour, not a granular solid.



VII. Installation Method

Measurements that do not involve direct contact with the liquid:

1. External accessories are required for installation

If external accessories, such as fixing fixtures, straps, or clamps, are used to secure the sensor,

a coupling agent must be applied between the sensor's transmitting surface and the bottom of the container being measured.

Common coupling agents include medical-grade petroleum jelly, 704 silicone, grease, and automotive lubricating grease (paste-like).

Silicone gaskets can also be used as coupling agents. However, using silicone gaskets will result in more signal attenuation compared to the paste-like coupling agents mentioned above.

Note: If the working environment will reach 0°C or below, do not use petroleum jelly. Because petroleum jelly contains moisture, at temperatures reaching or falling below 0°C,

the moisture will freeze, causing significant signal attenuation, or even preventing measurement altogether.

2. No external accessories are installed

A sufficiently viscous coupling agent must be placed between the sensor's transmitting surface and the bottom of the container being measured.

Commonly used coupling agents include 704 silicone, gel adhesive, and two-component adhesive.

Note: Different adhesives attenuate the signal differently after solidification.

3. Sensor installation location selection:

Because the ultrasonic waves emitted by the sensor are like the beam of a flashlight, forming a cone, the illumination range increases with distance. Therefore, it is crucial to ensure that the beam emitted by the sensor does not encounter any obstacles between the highest liquid levels.

4. The ultrasonic beam emitted by the sensor must be perpendicular to the surface of the liquid being measured.

5. The cables connecting the sensors to the computer, host computer, and PLC should be externally protected with conduits to prevent wear and damage in the field. Wear on the sensor cables can lead to incorrect received signals or even damage to the sensors themselves.

6. In environments with strong electromagnetic interference, the cables between the sensors and the computer, host computer, and PLC should be externally protected by flexible metal conduits or rigid metal pipes to shield against electromagnetic interference radiated from the air.

7. In environments with strong electromagnetic interference, a "DC-to-DC isolation power supply module" should be added to the power supply to shield against electromagnetic interference from the power supply section.

8. If connected to a PLC, DCS, or other host computer, there will be interference from the 485 cable, so a 485 signal isolator needs to be added between them.

9. If the cable is not long enough and an extension cord is used, ensure that the wiring is correct and that no liquid gets into the connection points.

10. Measurement accuracy is lower in vibrating environments than in non-vibrating environments.

Measurements involving direct contact with liquids:

1. The sensor needs to be fixed in the measurement position using a fastener.

The sensor's cable must also be secured to prevent it from swaying in the liquid or being impacted by the flowing liquid.

2. Because the sensor's emitting surface is in direct contact with the liquid, there is no need to coat the emitting surface with a coupling agent.

3. The ultrasonic beam emitted by the sensor must be perpendicular to the surface of the liquid being measured.

4. Sensor installation location selection:

Because the ultrasonic waves emitted by the sensor are like the beam of a flashlight, forming a cone, the illumination range increases with distance. Therefore, it is crucial to ensure that the beam emitted by the sensor does not encounter any obstacles between the highest liquid levels.

5. Precautions for environments with strong electromagnetic interference:

The cables connecting the sensors to the computer, host computer, and PLC should be externally protected with flexible metal conduits or rigid metal tubing to shield against electromagnetic interference radiated from the air.

In environments with strong electromagnetic interference, a DC-to-DC isolation power supply module should be added to shield against electromagnetic interference from the power supply section.

If connected to a host computer such as a PLC or DCS, interference may come from the RS-485 cable; therefore, an RS-485 signal isolator should be added between them.

6. Because the sensor is in a liquid, it is necessary to ensure that the sensor itself and the cable are not corroded or worn by the liquid.

7. If the cable length is insufficient, since both the sensor and the cable are immersed in liquid, extension cords are not allowed. You should contact the manufacturer to select a cable of sufficient length.

VIII. Precautions

1. The sensor itself must be reliably fixed and will not shake, vibrate, or shift due to water flow impact.
2. The sensor installation location will not be directly impacted by the liquid, and will not cause the sensor to collide with any hard objects.
3. Neither the sensor itself nor the cable will be directly impacted by flowing liquid.
4. The measurement location should avoid the inlet and outlet.
5. The presence of air bubbles, solid particles, suspended matter, or floating objects in the liquid will affect the measurement, for example, causing the maximum measurement distance to fall below the specifications. For example, detecting floating objects in the water will also output the distance to the floating object.
6. Ensure that the sensor and cable are not corroded, worn, or damaged by the liquid.
7. The sensor itself and the bracket should be separated by 2-3mm or thicker soft rubber to prevent vibrations during transmission from resonating with the bracket.
8. The aviation connector or direct cable on the top of the sensor must be properly protected. Otherwise, under the impact of water flow on site, the cable may wear, crack, break, fall off, or be corroded due to wear over time, ultimately leading to sensor damage.

IX. Output Settings

The sensor has a built-in 485 chip and uses the Modbus-RTU standard protocol.

Example of communication:

01 03 00 00 00 01 84 0A Read the distance value of the first path;

01 03 00 01 00 01 D5 CA Read the distance value for the second channel; (set to the level height value //not normally used)

01 03 00 02 00 01 25 CA Read the sensor temperature value.

Comprehensive instructions: 01 03 00 00 00 03 05 CB

Reply: 01 03 06 03 20 04 B0 08 34 A6 41

03 20 Distance value for route 1: 800mm //Large range distance value: 800cm

04 B0 Distance value for route 2: 1200mm

08 34 Temperature value: 21°C

X. Communication Protocol

1. Serial port parameter settings

The hardware uses RS-485, master-slave half-duplex communication, with the master calling the slave address and the slave responding.

The data frame is 10 bits long: 1 start bit, 8 data bits, 1 stop bit, and no parity.

Baud rate: 4800 9600 19200 38400 115200 (factory default is 115200).

Note: Baud rate settings are 00 for 4800, 01 for 9600, and so on.

2. Read a single register

Function code: 03H

Host sends							
1	2	3	4	5	6	7	8
ADDR	03H	Start register high byte	Start register low byte	Register Count high Byte	Register Count low byte	CRC code low byte	CRC code high byte

Byte 1 ADDR: Slave address code (0x01~0xFE);

Byte 2 03H: Function code;

Bytes 3 and 4: Address of the register to be read;

Bytes 5 and 6: Number of registers to be read, 0x0001 for reading a single register;

Bytes 7 and 8: CRC16 checksum from Byte 1 to Byte 6.

Slave Receive						
1	2	3	4	5	6	7
ADDR	03H	Total bytes	High byte of data	Low byte of data	CRC code low byte	CRC code high byte

Byte 1 (ADDR): Slave address code (0x01~0xFE);

Byte 2 (03H): Function code;

Byte 3: Total number of received data bytes. If reading a single register, the total number of bytes is 02;

Bytes 4 and 5: Register data, each data occupies 2 bytes;

Bytes 6 and 7: CRC16 checksum from byte 1 to byte 5.

3. Read multiple registers

Function code: 03H

Host sends							
1	2	3	4	5	6	7	8
ADDR	03H	Start register high byte	Start register low byte	Register Count high Byte	Register Count low byte	CRC code low byte	CRC code high byte

Referring to the method of reading [a single register](#), when reading distance and temperature simultaneously, the number of registers is 0x0002;

Slave Receive									
1	2	3	4、5		...	N-1、N		N+1	N+2
ADDR	03H	Total bytes	Data 1 high byte	Data 1 low byte	...	Data N high bytes	Data N low byte	CRC code low byte	CRC code high byte

Referring to the method of reading [a single register](#), data 1 is the starting register value to be read. Each data occupies 2 bytes, and the number of data returned depends on the number of registers read by the user.

4. Write a single register

Function code: 06H

Host sends							
1	2	3	4	5	6	7	8
ADDR	06H	Register address high byte	Register address low byte	High byte of data	Low byte of data	CRC code low byte	CRC code high byte

Byte 1 ADDR: Slave address code (0x01~0xFE);

Byte 2 06H: Function code;

Bytes 3 and 4: The address of the register being written;

Bytes 5 and 6: The register data corresponding to the register address;

Bytes 7 and 8: CRC16 checksum from Byte 1 to Byte 6.

Slave Receive							
1	2	3	4	5	6	7	8
ADDR	06H	Register high byte	Register low byte	High byte of data	Low byte of data	CRC code low byte	CRC code high byte

Byte 1 ADDR: Slave address code (0x01~0xFE);

Byte 2 06H: Function code;

Bytes 3 and 4: The address of the register being written;

Bytes 5 and 6: The register data corresponding to the register address;

Bytes 7 and 8: CRC16 checksum from Byte 1 to Byte 6.

5. Error code

1	2	3	4	5
ADDR	Function code	Error message codes	CRC code low byte	CRC code high byte

Byte 1 ADDR: Slave address code (0x01~0xFE);

Byte 2 83H or 86H: Function code (83H indicates a read instruction error, 86H indicates a write instruction error);

Byte 3: [Reference error message code table](#);

Bytes 4 and 5: CRC16 checksum from byte 1 to byte 3.

Error message code table	
Information code	Remark
01H	Illegal function code
02H	Invalid data address
03H	Invalid data values
04H	CRC16 check error
05H	Received correctly
06H	Receive error
07H	Parameter error

6. Register definition table

Register definition table									
Register address	Content Description			Read-only	Register address	Content Description			Read-only
0000	0	1	Distance	√	0001	2	3	Reading point value	√
0002	4	5	Temperature	√	0003	6	7	Reserve	√
0032	100	101			0033	102	103		
0034	104	105			0035	106	107	Set the level value (reference zero point)	
005C	184	185	//Active upload mode is 2		005D	186	187		
005E	188	189			005F	190	191		
0060	192	193			0061	194	195	Factory reset System reset	
0062	196	197	Baud rate settings METERWORK		0063	198	199	Pulse count	
0068	208	209			0069	210	211		

006A	212	213			006B	214	215	Table type ✓ Instrument address	
006C	216	217			006D				

Routine

Single-beam underwater ultrasonic distance sensor			
Instruction	Send	Receive	Comment
Read the instructions	01 03 00 00 00 01 84 0A	01 03 02 07 D0 BB E8	Distance value: 2000mm//Large range 2000cm
	01 03 00 02 00 01 25 CA	01 03 02 0B 31 7E A0	Temperature: 28.65℃
	01 03 00 01 00 01 D5 CA	01 03 02 17 70 B6 50	Level value: 6000mm
	01 03 00 00 00 02 C4 0B	01 03 04 07 D0 0B 31 3C 5A	Simultaneously read data from two registers
Write Instructions	01 06 00 5C 00 02 C8 19	01 06 00 5C 00 02 C8 19	Switch to active upload mode
	01 06 00 5C 00 00 49 D8	01 06 00 5C 00 00 49 D8	Switch to passive upload mode
	01 06 00 6B 00 02 79 D7	01 06 00 6B 00 02 79 D7	Given that the current instrument address is 01, change it to 02
	01 06 00 62 01 00 29 84	01 06 00 62 01 00 29 84	The baud rate was changed to 9600
	01 06 00 61 01 00 D9 84	01 06 00 61 01 00 D9 84	System factory reset
	01 06 00 61 00	01 06 00 61 00 01 19 D4	System Reset

	01 19 D4		
	01 06 00 35 17 70 97 D0	01 06 00 35 17 70 97 D0	Set reference zero point to 6000mm
Error Instruction	01 03 00 0C 00 01 44 09	01 83 02 C0 F1	02 indicates an error code: Illegal data address.

7. Agreement Description

① Temperature Value (REG_ADDR: 0001H) The temperature value is represented by 2 bytes of unsigned data. Divide the read value by 100 to obtain the temperature value, in °C. The highest bit of the high byte is the sign bit; 0 indicates positive, and 1 indicates negative. For negative temperature values, please [refer to the method for representing negative distance/level values](#).

② Query/Set Error Compensation (REG_ADDR: 0004H)

The error compensation value is represented by 2 bytes of unsigned data, in mm. This value can be used to slightly compensate for distance measurement errors exceeding the maximum allowable range. The default compensation value is 0. The compensation value is obtained by splitting the int16_t type data into two bytes, with the high byte first and the low byte last, in the same format as the numerical storage format in the computer.

Negative compensation value = 65535 - error value.

For example: If the error value is 35mm, the compensation value is 65500, which is 0xFFDC in hexadecimal.

The modification command is 01 06 00 04 FF DC 88 62. Positive compensation values are simply hexadecimal numbers.

For example: If the error value is 25mm, it is 0x0019 in hexadecimal. The modification command is 01 06 00 04 00 19 09 C1.

8. Protocol Supplements

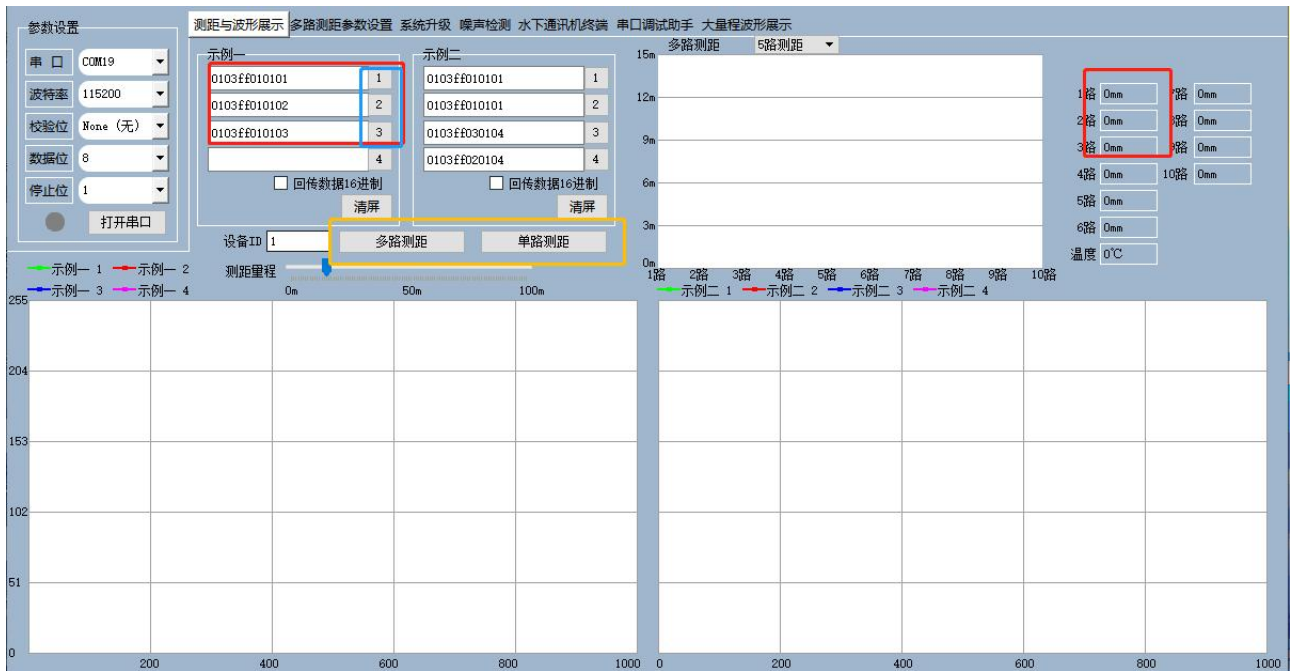
Special Specifications:

0103FF010105: Read the ASCII value of the full waveform data

0103FF010106: Read the hexadecimal value of the full waveform data

XI. Host Computer Operation Guide

1. Read waveform and distance value



As shown in the figure: First, you need to select the serial port and baud rate. After opening the serial port, read the waveform according to the instructions in Example 1.

Specifically,

the command "0103ff010101" corresponds to the original signal waveform;

"0103ff010102" corresponds to the filtered signal waveform;

"0103ff010103" corresponds to the long pulse signal waveform.

Clicking on multi-channel ranging allows you to read data such as distance, temperature, and sensitivity.

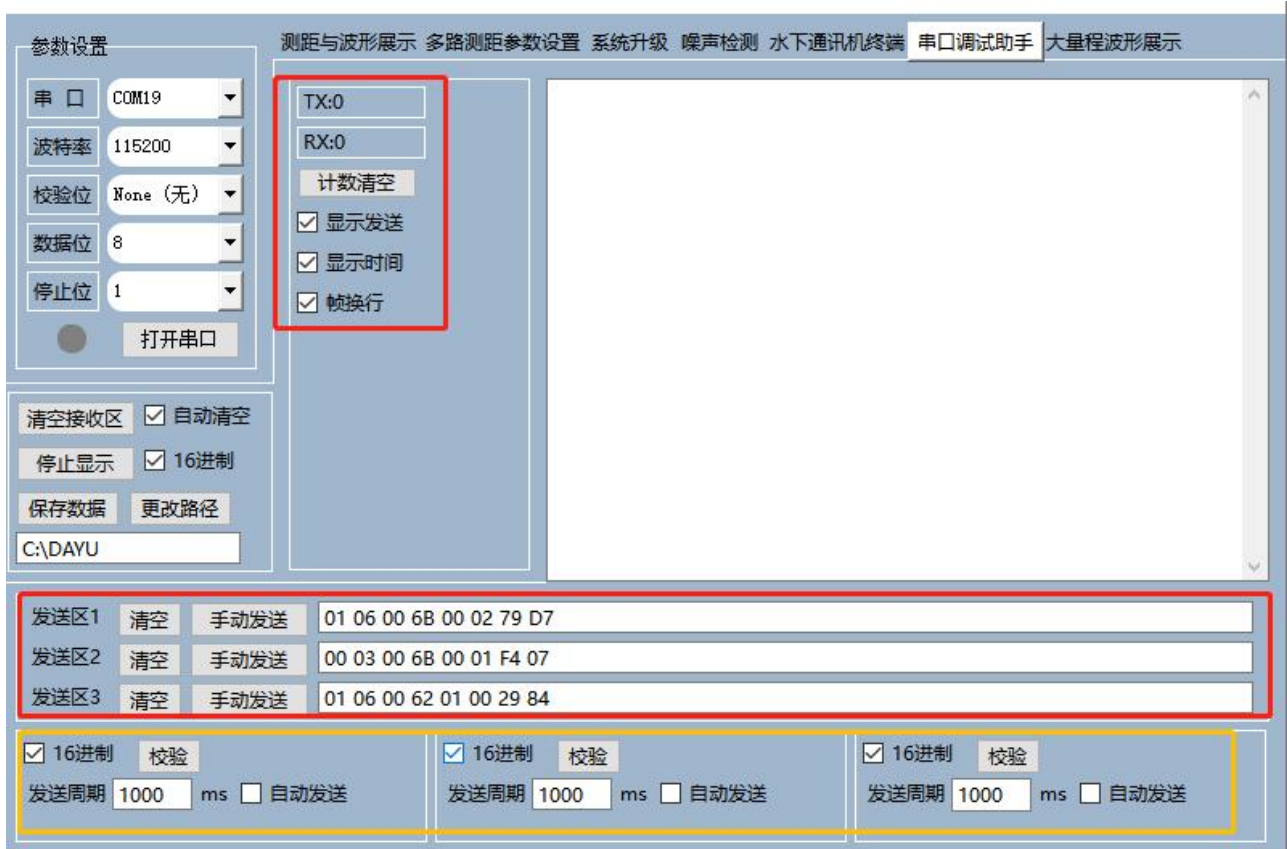
For example, in the image, channel 1 displays the distance value, and channel 3 displays the temperature value.

2. Factory reset



As shown in the image, to restore factory settings, simply click "Restore Factory Settings".

3. Serial Port Debugging Assistant



For commands to be sent/read via serial port assistant, refer to the register definition table and examples. Enter the value you want to modify or read in the send area.

For example: In the send area 1 of the image above, the command 01 06 00 6B 00 02 79 D7, where 79 D7 is the CRC checksum, will be sent successfully by clicking "Manual Send". TX is for sending, and RX is for receiving the return command.