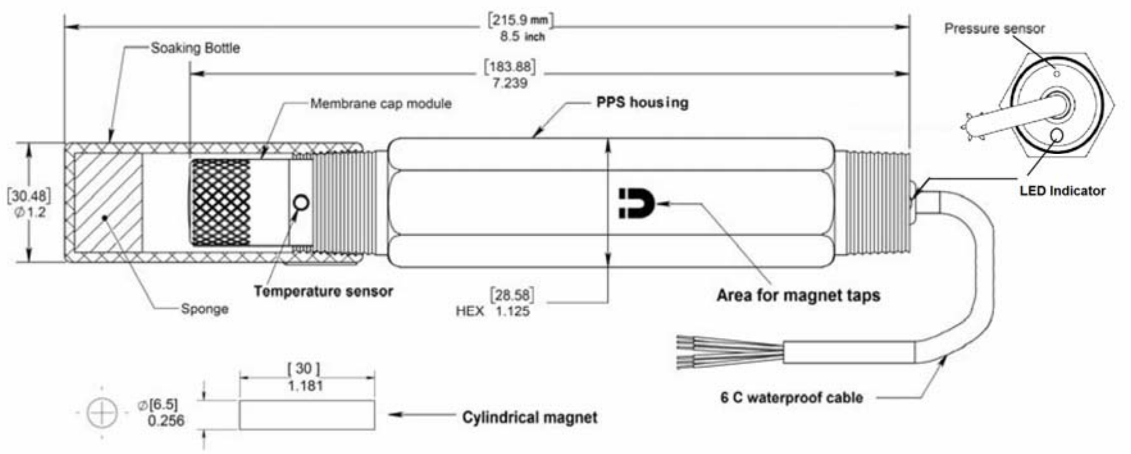
DOGB-0004 (0-5 V output) Optical Dissolved Oxygen Probe

DOGB-0004 optical dissolved oxygen probe utilizes fluorescence quenching technology to measure the concentration and saturation percentage of dissolved oxygen (DO) in an aqueous solution. The probe outputs 0-5 V corresponding to the oxygen concentration of 0-20 mg/L and the saturation of 0-200 %. The DO reading is automatically calculated and compensated by the integration data from temperature and pressure sensors and sophisticated algorithms in the firmware. The magnetic-controlled commands make sure the necessary functions can be done on the probe side with no software interface, and greatly simplify the user's setup of the controller. The integrated coefficient database also makes the sensor cap replacement convenient without external Micro SD card. The working temperature of this sensor is 0 - 50 °C while the pressure compensation scope is 51 - 112 kPa (0.5 - 1.1 atm). The water-proof pressure sensor can bear a maximum pressure of 10 atm.

Probe General Dimensions and Overview



Connections to power supply and customer controller are shown below

Wire color	Description
Red	Power (4.5 ~ 7 V DC)
Black	GND and the **black**/ground test probe of multimeter
Green	UART_RX (for upgrading or PC connection)
White	UART_TX (for upgrading or PC connection)
Yellow	DO (%) output and the **red**/V test probe of multimeter
Blue	DO (mg/L or ppm) output and the **red**/V test probe of multimeter

Note:

1) *The two UART wires can be cut if users do not need PC monitoring and firmware updates.*
2) *Outputting temperature or pressure (depth) is also optional based on the customer requirements.*
3) *The wire color might be changed and please refer to the manual attached to the probe.*

Conversion Equations

DO Concentration (mg/L) = 4.1667 × V - 0.4167 [V = voltage readings between blue and black wires]
DO Sat.% = (0.4167 × V'-0.0417) × 100% [V' = voltage readings between yellow and black wires]

Magnetic-controlled commands and LED indicator

Special commands can be performed using a magnetic switch controlled by a user's magnet. Tapping the magnetic marker of the probe is indicated with a bicolor red/blue LED. This LED is used to confirm the taps and the activation of the corresponding commands. The tap times, the related commands, and the LED conditions are all summarized in Table 1.

Table 1. Corresponding operations and commands of the LED indicator

Magnet taps = Red LED blinks	Commands	Blue LED confirming the command
1	Salinity off	1 blink
2	Salinity on (35 ppt)	2 blinks
3	1-point calibration	3 blinks

Note:

1) A successful magnet tap is related to a red LED blink, otherwise re-tap is needed.
2) Magnet tapping is similar to "Morse code", as an intended action for preventing the unexpected or accident magnetic trigger.
3) Time between taps must be less than 5 seconds for a single command.
4) No matter how long the magnet is held on the magnetic area of probe, it is counted as one tap.
5) To avoid accidentally calibrating probes during measuring, the 1-point calibration is set as 3 taps.

Calibration

Connect the probe to an appropriate meter or controller, and provide ~ 5 V DC to power the probe. 1-pt calibration for the 100% saturation can be done by any of the following means:

1) In air-saturated water (standard method with error < 0.5%).

Air-saturated water (for example in a 500 mL container) can be obtained by either continuously purging water with air using an air bubbler or some type of aeration for 3 to 5 minutes, or stirring water with a magnetic stirrer at 800 rpm for 1 hour. And then:

i) Immerse the sensor cap and temperature sensor of the probe in the air-saturated water and waiting until the reading becomes stable (usually 1 to 3 minutes).

ii) Tap the magnetic area of the probe 3 times using the magnet head to start the calibration.

iii) If the calibration is done successfully, the blue LED should blink 3 times. The related voltage output (between yellow and black wires) will be calibrated to 2.50 V, corresponding to the standard 100% saturation. If not, please redo the steps above.

2) In water-saturated air (convenient method and error < 2%).

Alternatively, the 1-pt calibration can be done using water-saturated air, but 0 to 2% error might occur. The recommended procedures are given below:

i) Immerse the sensor cap and temperature sensor of the probe in fresh/tap water for 1 to 2 minutes.
ii) Take the probe out and quickly tap dry the surface of sensor cap with a tissue.
iii) Put the sensor end of the probe in the calibration/storage bottle with a wet sponge and a small amount of water inside. Avoid direct contact of the sensor cap with any water in the calibration/storage bottle during this calibration step.
iv) Loosely screw the calibration/storage bottle onto the probe. Keep the distance between the sensor cap and the wet sponge being 1 ~ 2 cm. Be careful not to completely tighten the bottle on the probe to ensure the pressure inside the calibration/storage bottle is the same as ambient pressure.
v) Wait 3 to 5 minutes and then trigger the 1-pt calibration function using the magnetic method mentioned above. The related voltage output (between yellow and black wires) will be calibrated to 2.50 V, corresponding to the standard 100% saturation.

Salinity compensation

This ODO has a preset salinity compensation option to compensate for seawater and similar applications. It can be cancelled or selected by tapping the magnetic marker of the probe once and twice respectively. As shown in Table 1, two taps sets salinity compensation to 35 ppt, which is a typical seawater salinity concentration.

If manual salinity compensation is desired for other salinity values, a compensation factor “S” can be used to correct the DO concentration “mg/L” in salt water as follows:

DO “mg/L” (after correction) = DO “mg/L” (before correction) × S

Compensation factor $S = e^{x}$, where $x = (-\ [ppt] \times (0.017674 + (-10.754 + 2140.7/T)/T))$, where salinity is in parts per thousand (ppt) and temperature is in Kelvin (K). For example, in freshwater (“normal” mode) salinity is 0 ppt and S = 1, while in seawater mode (assuming the salinity level is 35 ppt), the factor is S = 0.816 (at 22^{o}C).

In addition, if users just have the conductance value, the conversion equation between salinity (in ppt) and specific conductance (SC in µS/cm) is:

$$ppt = 5.572\times10^{-4}(SC)+2.02\times10^{-9}\times(SC)\times(SC).$$

Coefficient change after sensor cap replacement

The probe has a preset database containing 10 groups of cap coefficients. The related group numbers are 0 - 9 for different sensor caps. Our sensor cap manufacturing process is quite stable and the given coefficient database covers all potential sensor caps for the lifetime of the probe. Thus, no update the database is needed unless a special announcement is made.

Each sensor cap has a 4-digit SN on the side and the last digit is the coefficient group number. If the new sensor cap has a different last digit than the previous one the new coefficients needs to be loaded, otherwise no update is needed. This operation is described in the Table 2.

Table 2. Magnet tap process for loading different coefficients

Step 1. Five magnet taps (5 corresponding red blinks by LED) for entering the coefficient selection mode.
Step 2. Wait until blue LED starts to blink. The blue LED will blink 5 times, but Step 3 can be started before the 5 blinks have finished. The blue LED will stop blinking if Step 3 is started.
Step 3. Tap the probe with the magnet a number of times equal to the last digit of cap SN. (A successful magnet tap will have a corresponding red LED blink, otherwise re-tap is needed)
Step 4. Observe blue LED after tapping. If the blue LED blinks = the last digit of cap SN, suggesting operation success. Otherwise, repeat Steps 1-4.

Note:

1) To load coefficient group 0, only do Step 1 and allow the blue LED blink to five times for confirmation

Maintenance

1) Probe maintenance includes cleaning the sensor cap, as well as the proper conditioning, preparation, and storage of the test system.

2) When the probe is not in use, it is highly recommended to store the probe with its sensor cap installed and the calibration/storage bottle which was included in the original packaging, threaded onto the probe. A beaker of clean water or a moist/humid capping mechanism can also suffice if the calibration/storage bottle is not available. The sponge inside the calibration/storage bottle should be kept moist for best results.

3) Avoid sensor cap touching organic solvent, scratching, and abusive collisions to strengthen and lengthen the working life of the sensor cap. Special care should be taken to clean the coating of cap, to dip probe and cap in fresh water, and then to tap dry the surface with a tissue. Do not wipe the coating surface.

4) Replace the sensor cap, if the cap coating is faded or stripped away. **DO NOT touch the clear window on the probe tip after unscrewing the old cap.** If any contaminants or residue are present on the window or inside the cap, carefully remove them with a powder free wipe. Then re-screw the new sensor cap onto the probe.

Preliminary Specifications:

Range: DO Saturation %: 0 to 200% DO Concentration : 0 to 20 mg/L (ppm) (wider ranges are possible upon request) Operating Temperature: 0 to 50°C Storage Temperature: -20 to 70°C Operating Atmospheric Pressure: 40 to 115 kPa Maximum Bearing Pressure: 1000 kPa Response Time: DO: T_{90} ~ 50s for 100 to 10% Temperature: T_{90} ~ 45s for 5 - 45°C (w/ stirring)	DO Compensation Factors: Temperature: automatic, full range Salinity: 0 or 35 ppt selected by the user Pressure: compensation by instantaneous pressure value if pressure sensor is above water or less than 20cm of water or compensation by default pressure value if the pressure sensor is more than 20cm of water. The default is taken from the pressure sensor during the last 1-point calibration and recorded in nonvolatile probe memory
Accuracy DO: 0-100% < ± 1 % 100-200% < ± 2 % Temperature: ± 0.2 °C Pressure: ± 0.2 kPa	Resolution: Low range (<1 mg/L): ~ 1 ppb (0.001 mg/L) Mid range (<10 mg/L): ~ 4-8 ppb (0.004-0.008 mg/L) High range (>10 mg/L): ~10 ppb (0.01 mg/L)* **The higher range, the lower resolution*
Calibration: 1-point (100% cal point) in air-saturated water or water-saturated air (calibration bottle)	Expected Sensor Cap Life: A useful life of up to 2 years is feasible in optimum situations
Input/output: Input: 4.5 - 7 V DC. Consumption: average 70 mA at 5V Output: Two 0-5 V lines	Others: Waterproof: IP68 Certifications: RoHs, CE, C-Tick (in process) Materials: Ryton (PPS) body Cable length: User specified