

Onset's HOBO Dissolved Oxygen Logger Uses the Latest Advancements in Optical Measurement Technology

RDO Basic Technology provides high-quality data and robust performance in many environments

Dissolved oxygen (DO) is one of the most important parameters monitored when evaluating water quality, aquatic biology, and other environmental and industrial processes. Water quality professionals will benefit from Onset's use of the Rugged Dissolved Oxygen (RDO®) Basic optical sensor technology from In-Situ Inc. The HOBO U26 Dissolved Oxygen Logger combines the high accuracy, robust performance of RDO Basic technology with an easy-to-maintain design – all at a fraction of the cost of other DO monitoring options.

What methods are used to determine DO?

Traditional methods for DO determination include the Winkler titration method and electrochemical methods, such as polarographic (Clark cell) and galvanic probes. With electrochemical methods, molecular oxygen is consumed by an electrochemical process. Two dissimilar metal electrodes (anode and cathode) are in contact with an electrolyte solution. A semi-permeable membrane separates the electrodes from the sample. As oxygen molecules diffuse through the semi-permeable membrane, they are reduced at the cathode to form positively charged ions. The ions migrate to the anode where an oxidation reaction occurs. The oxidation/reduction reaction generates an electrical current that is directly proportional to the oxygen concentration.

Optical sensor technology takes a different approach to quantifying DO. Originally introduced in the 1970s, recent developments have allowed for the production of cost-effective probes that operate in demanding environments (Figure 1).

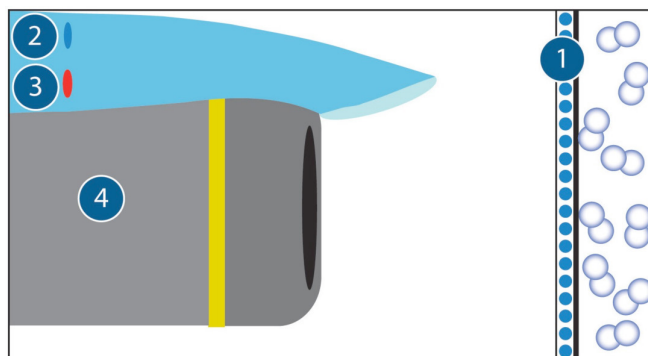


Figure 1. RDO Basic sensor includes lumiphore molecules (1) embedded in a sensing element, blue LED (2), red LED (3), and photodiode (4)

When the RDO Basic sensor initiates a reading, a blue LED emits blue light, which excites the lumiphore molecules. Excited lumiphore molecules emit red light, which is detected by a photodiode (Figure 2). Oxygen molecules quench the excited lumiphore molecules and prevent the emission of red light. This process is called “dynamic luminescence quenching.”

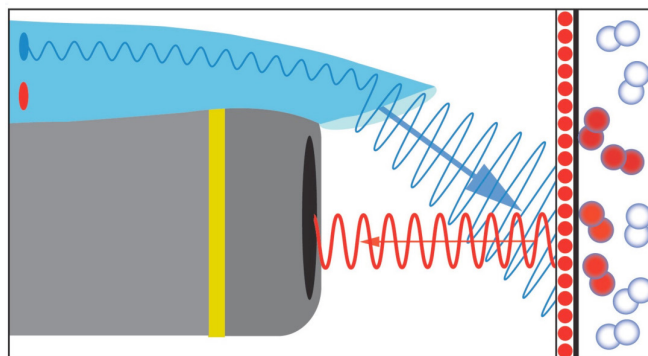


Figure 2. Lumiphore molecules are excited by blue light and emit red light, which is detected by a photodiode

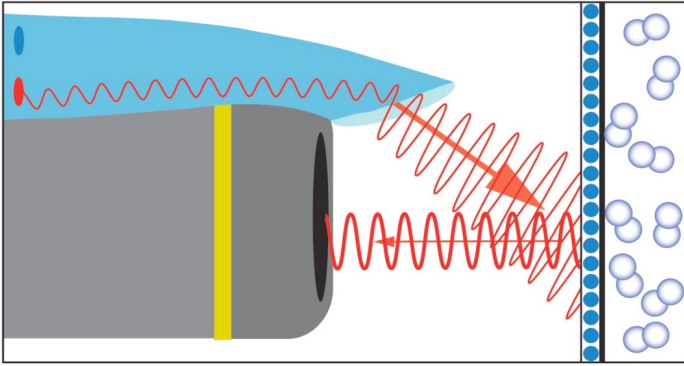


Figure 3. Optical electronics compute luminescence lifetime. The luminescence lifetime is based on the phase shift between the red returned light from the excited lumiphore molecules and the red reference light from the red LED.

The RDO Basic sensor measures a phase shift between the red returned light and the red reference light (Figure 3). DO concentration and red returned light are inversely proportional. For example, high DO concentration reduces red returned light. Optical electronics calculate DO concentration and report results in mg/L. Determination of DO concentration by luminescence quenching has a linear response over a broad range of concentrations and offers a high degree of accuracy and stability.

How do optical technologies differ?

Luminescence intensity measurements are not stable. Typically, luminescence lifetime methods are used to determine DO concentration. Luminescence lifetime can be measured by using either a time domain method or a frequency domain method.

- 1. Time Domain Method** —Uses a pulsed measurement method to measure a single or an average of a series of exponential decay events. This method is susceptible to drift and interference from stray light.
- 2. Frequency Domain Method** —Measures the phase shift between the entire signal and references wave forms across a number of cycles (Figure 4). This method delivers the highest accuracy across the widest operating range. The RDO Basic sensor uses this method, which delivers accurate, stable results.

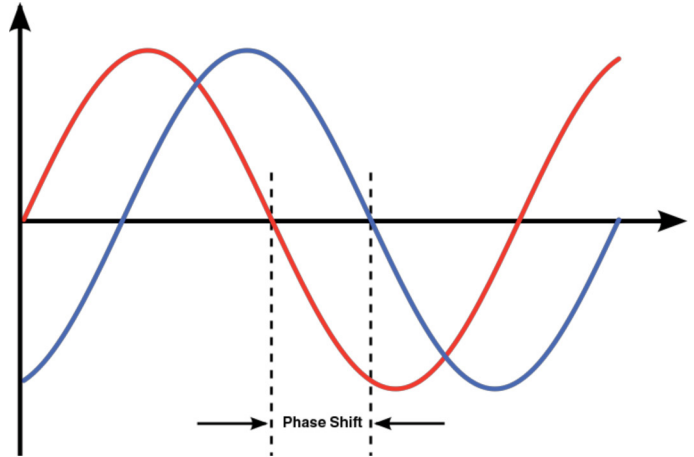


Figure 4. The luminescence lifetime is based on the phase shift between the red returned light from the excited lumiphore molecules and the red reference light from the red LED.

What problems are eliminated with optical technology?

Until the development of optical DO technology, the ability to accurately monitor DO levels over long periods of time was limited. Electrochemical methods require sample stirring or flow and are functionally limited by the durability of their membrane. In addition, galvanic diffusion methods typically have slow response.

Optical DO technology eliminates the need for:

- Complex sensor storage and conditioning
- Sample flow and stirring
- Frequent calibration
- Membrane and electrolyte solution replacement

Electrochemical sensors, no matter the level of biofouling, require a site visit at a minimum of every two weeks for maintenance and recalibration. Environmental professionals can deploy the optical RDO Basic sensor for an entire monitoring season, spanning months, without calibration, and can obtain accurate results in high-fouling environments, without the need for stirring or sample flow. Though DO sensors are subject to interference from active fouling, the optical RDO Basic sensor can be cleaned and redeployed without recalibration. Electrochemical sensors require frequent recalibration and replacement of the membrane and electrolyte solution.

Variable	Galvanic	Polarographic Steady State	Polarographic Pulsed	Optical Life*
Flow dependence	Low	High	Low	None
Response time (to 90%)**	Slow	Medium	Medium	Fast
Range (0-200%) Low end (0-1 ppm) High end (20 ppm)	Yes + ++	Yes + ++	Yes + ++	Yes ++ +
Long-term stability	+	+	+	++
Frequency of maintenance	High	High	High	Low
Calibration Zero point required Factory or lab Difficulty	No F N/A	No F/L Medium	No F/L Medium	No F N/A
Notes	* Optical life is synonymous with optical lifetime. ** Slow ≈ 7 minutes; Medium < 1 to 3 minutes; Fast < 1 minute ++ indicates better performance than +			

Table 1. The Alliance for Coastal Technologies (ACT) conducts field tests that compare different technologies. In 2004, ACT tested galvanic, polarographic, and optical probes in field conditions. The table above is a comparison of DO measurement technologies produced for the ACT Workshop Proceedings, January 2004. (State of Technology in the Development and Application of Dissolved Oxygen Sensors, University of Maryland Technical Report Series No. TS-444-04-CBL, p. 11.

What are the advantages of RDO® Basic technology?

- **Accurate results** — The sensor operates with no drift over long-term deployments. And, unlike membrane-based sensors, the RDO Basic sensor excels in hypoxic conditions. No sample flow or stirring is required.
- **Minimal maintenance** — The sensor face requires periodic cleaning, and sensor caps are replaced every six months. No hydration, conditioning, or special storage is required. Membranes and electrolyte/filling solution are eliminated.
- **Long-lasting calibration** — When biofouling is minimal, the factory-calibrated RDO Basic sensor does not require calibration for long periods of time because it is not susceptible to drift due to the use of a non-consumptive, non-reactive method. Membrane-based sensors typically require calibration every two weeks, depending on sample conditions.
- **Rugged performance** — The abrasion-resistant sensing element withstands fouling, high sediment loads, and rapid flow rates. The lumiphore is not affected by photobleaching or stray light. In addition, unlike membrane-based sensors, the RDO Basic sensor is unaffected by sulfides, sulfates, hydrogen sulfide, carbon dioxide, ammonia, pH, chloride, and other interferences.
- **Automatic setup** — The RDO Basic sensor's cap includes pre-loaded calibration coefficients, serial number, expiration clock, and manufacture date for traceability. These features eliminate programming errors and improve ease-of-use.
- **Patented signal processing** — Proprietary design allows for stable, fast response and has low power requirements. The RDO Basic sensor is ideal for long-term deployments, dynamically changing conditions, and vertical profiling.

Technology Backgrounder

About Onset

Onset is the world's leading supplier of data loggers. Our HOBO data loggers, data nodes, and energy logging systems can be rapidly deployed in a wide range of energy management applications, including energy audits, Measurement & Verification, building commissioning and indoor air quality studies. Based on Cape Cod, Massachusetts, Onset has sold more than 2 million data loggers since the company's founding in 1981.



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