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JAC-OCEAN NEWS
August 2015

RINKO FT ~ *A new member of the RINKO family* ~

We are pleased to announce the launch of our new dissolved oxygen (DO) sensor, ***RINKO FT*** (model name: ***ARO-FT***). The *RINKO* series is based on the optical (phosphorescence) principle which is now widely known as a remarkably fast response oxygen sensor with a high accuracy. As a new member of the *RINKO* family, the ***RINKO FT*** had overcome a well-known tradeoff between fast responsivity and stability of an oxygen sensing foil. The ***RINKO FT*** not only ***retains the fast response time*** identical to that of conventional *RINKO* series but also has ***greater accuracy and stability*** by incorporating ***high-quality multipoint calibration*** and ***improved sensing method***. The ***RINKO FT*** is primarily designed to target Argo float operations, however, its compact, lightweight, and commonly used communication protocol widen the choice of platforms for installation. The ***RINKO FT*** enables DO measurements with a high vertical resolution, which will contribute to the understanding new aspects of physical/biochemical processes.

Float and CTD sensors not manufactured by JFE Advantech.

RINKO FT features

- ✓ ***Fast response (63%: less than 1 s in water)***
- ✓ ***Multipoint factory calibration***
- ✓ ***User-friendly calibration***
- ✓ ***High accuracy and long-term stability***

Fast response

The most outstanding feature of the *RINKO* series is the extremely fast responding time of the oxygen sensing foil (63% response time: ***less than 1 s in water***, as shown in Fig. 1). This feature enables DO measurements with a high vertical distribution. By resolving small-scale DO distributions, the ***RINKO FT*** can assist in revealing a fine structure of physical/biochemical processes.

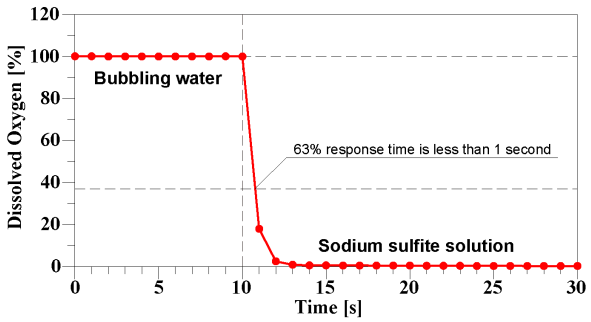

Figure 1: Time series of dissolved oxygen (DO) in water at 25 °C, as measured by the *RINKO FT*. Air saturated water (DO = 100 %) is created by bubbling for 30 minutes. Anoxic water (DO = 0 %) is created by dissolving 50 g of Na_2SO_3 in 1000 ml of distilled water.

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Multipoint factory calibration

The ***RINKO FT*** is calibrated with the Stern–Volmer equation, expressed in terms of phase-shift data (Uchida *et al.*, 2010) to achieve absolute high accuracy (±2% of the measured value or ±2 µmol/L). Coefficients are determined using a 16-point calibration (four temperatures and four oxygen concentrations). The four oxygen reference standards are produced by ***saturating the Primary Mixture (National Metrology Institute of Japan (NMIJ) certified traceable gases) individually*** with each oxygen concentrations of approximately 4%, 10%, 17%, and 25%. These values correspond to an air saturation of approximately 20%, 50%, 80%, and 120%, respectively. ***The Winkler titration method is NOT applied*** to our multipoint calibration in order to minimize systematic and experimental errors.

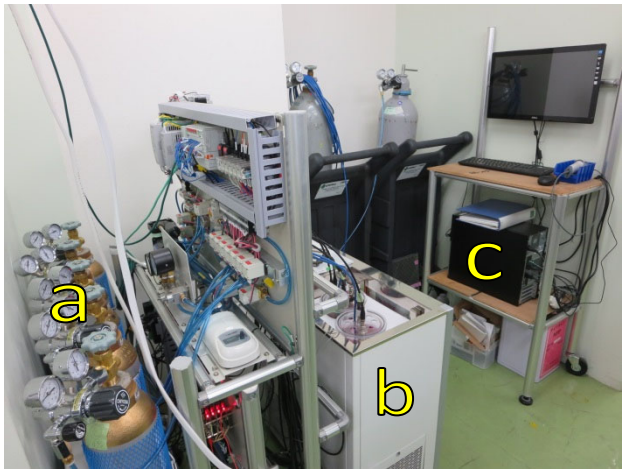

Figure 2: Multipoint calibration system installed in our factory. a) 5 tanks of the highest grade traceable gases for calibration (4 tanks) and verification (1 tank). b) Isothermal bath. c) Control PC.

The measured values of the calibrated ***RINKO FT*** are verified using oxygen reference water produced by ***saturating the Primary Mixture***. The oxygen concentration of the traceable gas used in the verification is approximately 21%, which corresponds to an air saturation of approximately 100%. Our verification assures that all residual errors of the measured DO values stay within 2% of measured value or ±2 µmol/L (whichever is greater) at four arbitrary temperature points of approximately 3, 10, 20, and 30 °C.

User-friendly calibration

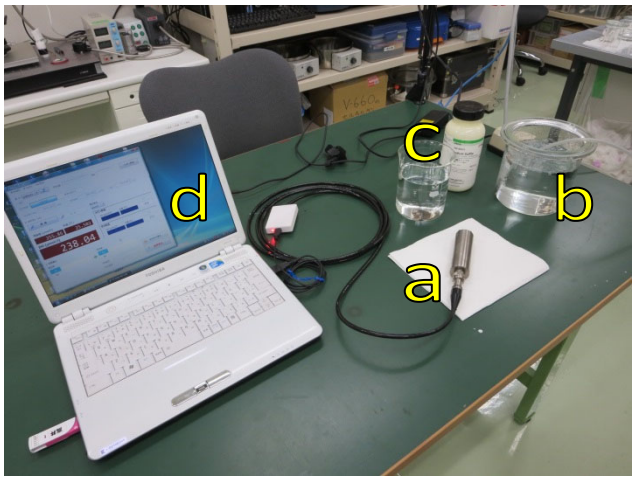

Figure 3: Operation of the user calibration. It is possible to perform not only a simple two-point calibration but also any kind of calibration method. a) *RINKO FT* with USB cable. *RINKO FT* is powered by USB port. b) Bubbling water. c) Sodium sulfite solution. d) GUI software.

The Argo floats, which the ***RINKO FT*** focuses on, are generally not recovered or post-calibrated. Therefore, the ***RINKO FT is designed to satisfy the required accuracy for a number of years without the need for re-calibration***. If the ***RINKO FT*** is installed on a platform different from an Argo float, it is preferable to perform the user calibration regularly in order to maintain the best accuracy. For this purpose, a "user calibration kit" is available as an option which includes a cable and GUI software. The ***RINKO FT*** can be easily detached without disturbing the mounting-hole mechanism or the wiring of the platform.

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High accuracy and long-term stability

The performance of the ***RINKO FT*** was evaluated during the Argo Program. Two MRV S3A floats with ***RINKO FT*** were launched from R/V *Mirai* by Japan Agency for Marine-Earth Science and Technology (JAMSTEC) in the northwestern Pacific Ocean on July 21, 2014. These floats recorded DO data ***every 2 dbar*** to take advantage of the fast responsivity of the ***RINKO FT***. The data from these floats are freely available on the Argo website. Fig. 4 shows the trajectory of the SN 7251 float, which drifted in the northwestern Pacific Ocean regions off Hokkaido and Tohoku. The first vertical profile of the ***RINKO FT*** DO data is plotted against the Winkler titration data sampled at the nearest site in Fig. 5. The figure shows that the ***RINKO FT DO concentrations agreed well with the Winkler DO concentrations***. Moreover, vertical high-resolution measurements have made possible to ***detect the subsurface DO maximum and minimum***.

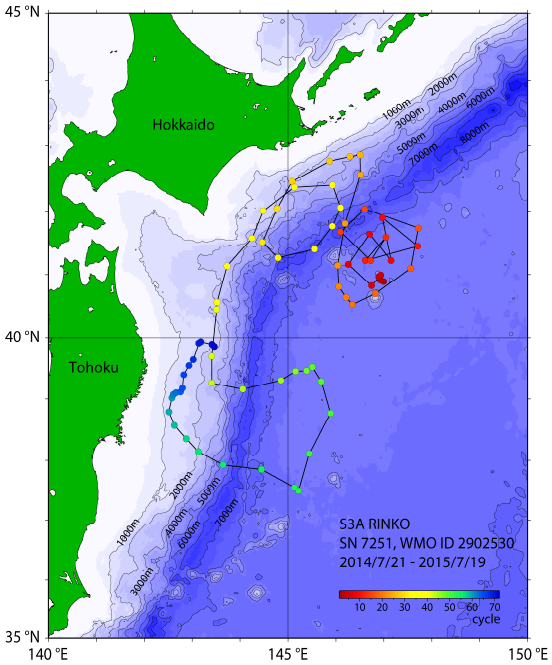
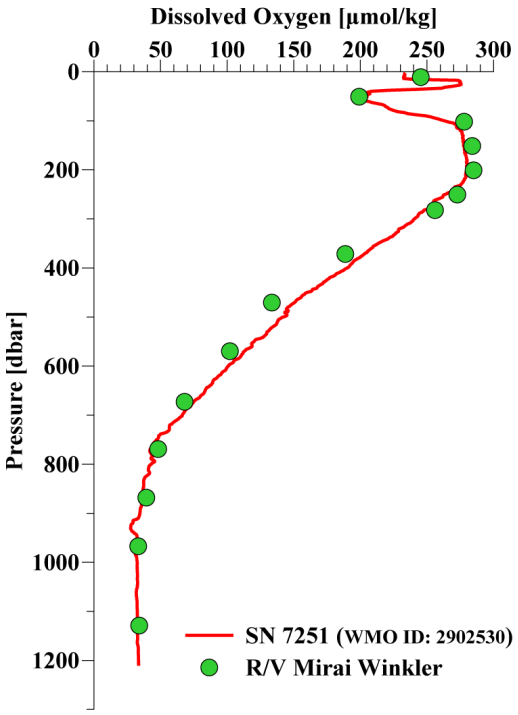


Figure 4: Trajectory of the S3A *RINKO* float (SN 7251, WMO ID 2902530), which records pressure, salinity, temperature, and DO profiles from a depth of 2000 m to the surface every 2 dbar at about 5-day intervals. The parking depth is 1000 m. The SN 7251 float is successfully operating as of July 2015.



The ***RINKO FT*** oxygen sensing foil ***possesses both a fast responsivity and long-term stability***, which is making this sensor unique. In general, a trade-off relationship exists between fast responsivity and stability of an oxygen sensing foil. In order to overcome such relationship, the sensing method of the ***RINKO FT*** has been improved by minimizing the LED emission time, which accelerates deterioration of the oxygen sensing foil. Fig. 6 shows a time series of the SN 7251 float data at a potential density of 27.6 σ_θ. The linear regression fitted to the DO data shows that there is ***no remarkable time drift (less than 0.7 µmol/kg per year)***.

It should be noted that the ***RINKO FT*** DO data on the Argo website labeled as ***"real-time QC mode data"*** are displayed ***without any additional correction***. Therefore, the ***RINKO FT*** DO data are ***ready for scientific purpose immediately after the float measurement***.

Figure 5: First vertical DO profile obtained with the *RINKO FT* installed on the MRV S3A float SN7251, and Winkler data from discrete water samples of the R/V *Mirai* MR14-04 cruise station 50 (green circle). The first profiling location of the float was 6 km apart from station 50, and the time difference between the float data and the Winkler data was 12 h. DO data are converted from µmol/L to µmol/kg in "real-time QC mode data".

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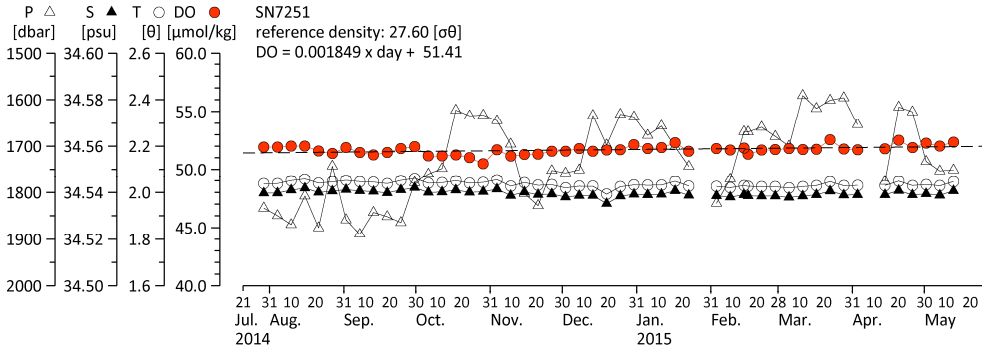


Figure 6: Time series of pressure (open triangle), salinity (filled triangle), potential temperature (open circle), and DO (red circle) recorded by float SN 7251 at a potential density of 27.6 σ_θ. The broken line represents the linear regression fitted to the DO data. The data after mid-May of 2015 are not shown as the float was drifting in shallow coastal regions near the Tohoku coast.

References

Uchida, H., G. C. Johnson, and K. E. McTaggart (2010): CTD Oxygen Sensor Calibration Procedures. *The GO-SHIP Repeat Hydrography Manual: A Collection of Expert Reports and Guidelines. IOCCP Report No. 14, ICPO Publication Series No. 134, Version 1.*

Acknowledgements

The sensor development and the performance evaluation of the *RINKO FT* installed on the MRV S3A float were implemented in collaboration with Japan Agency for Marine-Earth Science and Technology (JAMSTEC). The Argo data were collected by the International Argo Program and the many affiliated national programs and are available through the Global Data Assembly Centers at http://www.coriolis.eu.org/ and http://www.usgodae.org/. Argo is a major contributor to the World Climate Research Programme (WCRP)'s Climate Variability and Predictability Experiment (CLIVAR) project and to the Global Ocean Data Assimilation Experiment (GODAE). The Argo array is part of the Global Climate Observing System / Global Ocean Observing System (GCOS / GOOS).

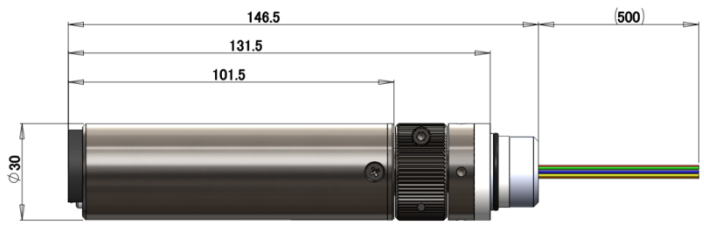
Specifications

Subject to change without notice.

Measurement principle	DO	Phosphorescence
	Temperature	Thermistor
Range	DO	Concentration: 0 – 425 µmol/L [1], Air saturation: 0 – 200% (calibration range: 0 – 120%)
	Temperature	-3 – 45 °C (calibration range: 0 – 35 °C)
Resolution	DO	0.01 µmol/L
	Temperature	0.001 °C
Initial accuracy	DO	±2% of measured value or ±2.0 µmol/L
	Temperature	±0.01 °C
Repeatability	DO	Time drift: ±5% of measured value/year or ±5.0 µmol/L/year Pressure effect: ±2% of measured value or ±2.0 µmol/L [2] Temperature effect: ±2% of measured value or ±2.0 µmol/L
Response time (63%) (at 25 °C, typical)	DO	< 1 s (from air saturated water to anoxic water)
	Temperature	< 1 s
Representative output parameters	DO in µmol/L, Temperature in °C, Engineering values of DO and temperature, Number of LED emission times, etc.	
Sampling interval	1 s (shorter interval at request)	
Pre-heat time	5 s	
Communication	UART (3.3 V logic) or RS-232C	
Communication protocol	Baud rate: 38400 bps, No parity, Handshake	
AD Converter	16-bit digital	
Power	6 – 26 VDC, 12 VDC recommended	
Current drain (at 12 VDC, typical)	Sampling: 30 mA, Sleep mode: < 0.1 mA	
Material	Housing: Titanium, Insulating attachment: POM	
Dimensions	Φ 30 × 146.5 mm with standard mounting attachment	
Weight	In air: 265 g with standard mounting attachment and 50 cm cable, In water: 162 g (design value)	
Pressure rating	2000 dbar (higher rating at request)	

1) Calculated from air saturation at 25 °C and 34 PSU. 2) Pressure hysteresis is not considered.

Dimensions



Dimensions are in mm.

RINKO FT is easily detached from standard mounting attachment. A cable with a connector instead of the standard attachment is also available. Enquire for special connectors.