取 A-0133-05

Fast optical DO sensor for integration

RINKO FT

(Model name: **ARO-FT**, **AROD-FT**)

User's Manual

CE

For safe use

1. Use after thoroughly reading this manual.
2. Improper use can lead to accidents.
3. Safely keep this manual in order not to lose it.

JFE Advantech Co., Ltd.

Introduction

- RINKO FT (model name: ARO-FT, AROD-FT) is a small, fast-response, and high-precision sensor for measurements of water temperature and dissolved oxygen (DO).
- The communication method can be selected from UART (3.3V logic) and RS-232C according to the float specifications.
- Possible to attach/detach the main unit without changing the float inner pressure for calibration/inspection.
- Span/zero calibration is possible by the calibration kit (optional).

Table of Contents

1 Terminology and Part Names

1.1 Terminology

Term	Description
Instrument	Refers to RINKO FT (ARO-FT/AROD-FT).
Physical quantity	Refers to values, such as water temperature and DO, calculated from the AD value with calibration coefficients.
Standard type (ARO-FT)	Refers to RINKO FT with standard mounting attachment.
Cable type (ARO-FT)	Refers to RINKO FT with LEMO connector.
MCBH type (AROD-FT)	Refers to RINKO FT with MCBH connector for deep sea (6700 m).

1.2 Part names

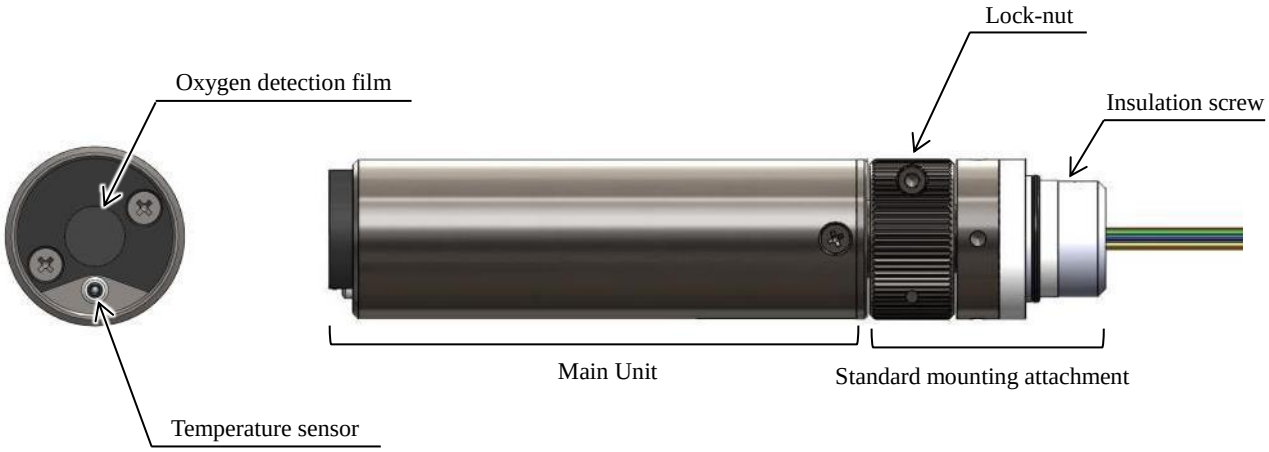


Figure 1.1 Standard type (ARO-FT)

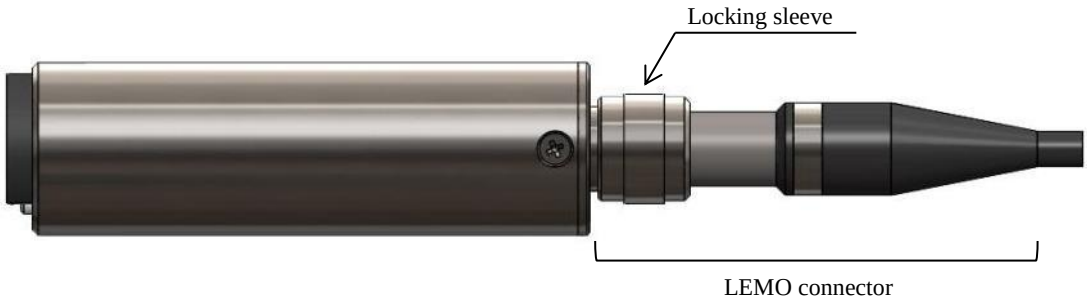


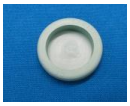
Figure 1.2 Cable type (ARO-FT)

Figure 1.3 MCBH type (AROD-FT)

2 Package Contents

2.1 ARO-FT

(1) Basic Package

No.	Items		QTY.
1	ARO-FT main unit		1
2	Protection cap		1
3	Standard mounting attachment or 3m cable with LEMO connector and pigtail end	 	1
4	User's Manual (this manual)		1
5	Calibration certificate		1

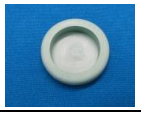
Note: the above list indicates the basic package. The content may differ depending on the order.

(2) Optional parts

No.	Items		QTY.
1	Cable with LEMO connector and USB converter		1
2	Application CD		1
3	Bubbling kit		1
4	Mini-USB cable		1

2.2 AROD-FT

(1) Basic Package

No.	Items		QTY.
1	AROD-FT main unit		1
2	Protection cap		1
3	Dummy cap		1
4	User's Manual (this manual)		1
5	Calibration certificate		1

Note: The above list indicates the basic package. The content may differ depending on the order.

(2) Optional parts

No.	Items		QTY.
1	Cable with MCIL and D-sub 9 pin connectors		1
2	Application CD		1
3	Bubbling kit		1

3 Safety Warning

Make Sure to Read This before Use

Danger	Indicate[s] a hazardous situation which, if not avoided, will result in death or serious injury. The signal word "DANGER" is to be limited to the most extreme situations.
Warning	Indicate[s] a hazardous situation which, if not avoided, could result in death or serious injury.
Caution	Indicate[s] a hazardous situation which, if not avoided, could result in minor or moderate injury.
	Indicates general precautions.
	Indicates supplements to control method and convenient functions.

Danger

- **Ensure safety for operations on water or ships.**

Warning

- **Do not damage the cables.**
- **Do not modify.**
- **Do not use it with a power supply beyond the rated values.**
- **Do not disassemble.**
  It can cause fire or electrocution.
- **Do not directly look at the excitation light for a long time.**
  It can damage the eyes.

⚠ Caution

- **Do not apply strong force or impact on the sensor.**
  It can lead to damage, which may cause injury and seepage of water into the instrument.
- **Do not hang by holding only the lead wire.**
  It can lead to a broken wire or damaged instrument.
- **Make sure to insert the connector completely up to its base.**
  It may cause seeping of water into the instrument.
- **Do not leave the instrument in a place with high temperature (e.g. under direct sunlight) for a long time.**
  It can accelerate the degradation of the oxygen detection film.
- **When attaching, make sure to tighten the screw all the way.**
  Loosely attached screws can compromise the water-proof property and may cause seeping of water into the instrument.

4 Precautions for Usage

4.1 Use of instrument

(1) This is a group 1, class B product according to EN 55011 (CISPR 11). This means that this product does not generate and/or use intentionally radio-frequency energy, in the form of electromagnetic radiation, inductive and/or capacitive coupling, for the treatment of material or inspection / analysis purpose and that it is suitable for use in domestic establishments and in establishments directly connected to a low voltage power supply network which supplies buildings used for domestic purposes.

(2) This instrument is designed for residential and commercial environment. Not permitted to use for industrial environment.

(3) After every use, clean with fresh water, remove moisture with a soft cloth, and store securely.

(4) Please do not touch the temperature sensor directly. It may damage the sensor. Static electricity may damage the parts used for this instrument. Take countermeasures to prevent damage from static electricity during maintenance and others since it may damage the instrument.

(5) The oxygen detection film is highly delicate and requires handling with care. Significant damage causes inaccurate data and requires a replacement of the oxygen detection film.

(6) When not in use, place the protection cap and turn off the power supply.

(7) Do not drop the instrument or apply impact.

(8) Before touching the instrument, release static electricity by touching a metal.

(9) As storage location, avoid places with temperature above 40 °C, high humidity, or high amount of dust.

(10) If the instrument was not used for a long time, inspect each part before connecting to the power supply.

(11) When using the instrument in water, it is recommended to use it at 30 °C or below. When it is used in water at 30 °C or above, the tracking for correction of temperature change can slow down, requiring more time to resume to the normal value.

(12) The insulation screw is for preventing electrolytic corrosion due to contacts between different metals.

(13) Use cables included with the instrument or specified cables only, and follow the use method specified in the manual when deploying the instrument. Using this instrument in any way not described in this manual may reduce the effectiveness of the instrument's protective functions. In case of replacing any parts and/or consumables, please make sure to use those specified by our company. Please feel free to contact us with any questions.

Cable list for ARO-FT

No.	Interface	Max. Cable Length, Shielding	Cable classification
1	DC Input/RS-232C port	3m, shielded	Signal and DC Power Line
2	DC Input/RS-232C/UART port	1m, Un-shielded	Signal and DC Power Line

Cable list for AROD-FT

No.	Interface	Max. Cable Length, Shielding	Cable classification
1	DC Input/RS-232C port	1.5m, Un-shielded	Signal and DC Power Line

4.2 Software

(1) It is prohibited to copy or reproduce part or whole of the software without JFE Advantech's written approval.

(2) The content and specifications may change without notice.

(3) We try our utmost to comprehensive content, but please contact JFE Advantech for any suspicion or suggestions.

(4) In this user's manual, Microsoft® Windows® 7, Windows 8, Windows 8.1 are used for demonstrations. Computer's control display or method may be different depending on the environment used.

- Windows® official name is Microsoft® Windows® Operating System.
- Microsoft® Windows®, Windows vista / 7 / 8 / 8.1 / 10 , .NET Framework are registered trademarks of Microsoft Corporation in the United States and other countries.

4.3 Disposal

When disposing of this product, ensure to abide by law and regulations.

5 Method for Connection

5.1 Wiring

5.1.1 Standard type (ARO-FT)

The wire color varies depending on the communication method, UART (3.3V logic) or RS-232C. Make the connection after checking the communication method.

(RX and TX are from the instrument side.)

Color	UART (3.3 V logic)	RS-232C
Red	Power input (6 - 26 VDC)	
Black	GND	
Green	FG (1)	
Yellow	N.C. (2)	RX
White	N.C. (2)	TX
Blue	RX (3)	N.C. (2)
Grey	TX	N.C. (2)

Note (1): FG (Frame Ground) to protect the instrument from noises coming from the outside, which will be connected to the frame of the platform. It could also be connected to GND if necessary.
Note (2): Do not connect wires to N.C. ports. It can damage the instrument.
Note (3): 100 kΩ pull-down

5.1.2 Cable type (ARO-FT)

The Cable type is only for RS-232C communication.

(RX and TX are from the instrument side.)

Green	RS-232C
Red	Power input (6 - 26 VDC)
Black	GND
Green	FG (1)
Yellow	RX
White	TX

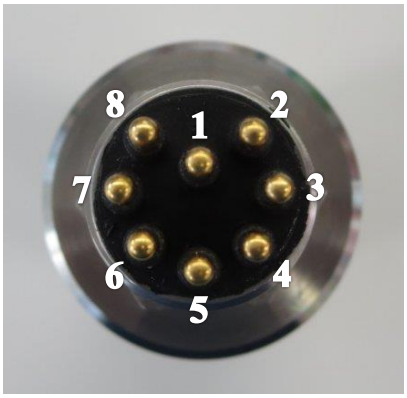
Note (1): FG (Frame Ground) to protect the instrument from noises coming from the outside, which will be connected to the frame of the platform. It could also be connected to GND if necessary.

5.1.3 MCBH type (AROD-FT)

The MCBH type is only for RS-232C communication.

(RX and TX are from the instrument side.)

Pin No.	RS-232C
1	N.C. (1)
2	RX
3	TX
4	N.C. (1)
5	FG (2)
6	N.C. (1)
7	GND
8	Power input (6 - 26 VDC)



Note (1): Do not connect wires to N.C. ports. It can damage the instrument.
Note (2): FG (Frame Ground) to protect the instrument from noises coming from the outside, which will be connected to the frame of the platform. It could also be connected to GND if necessary.

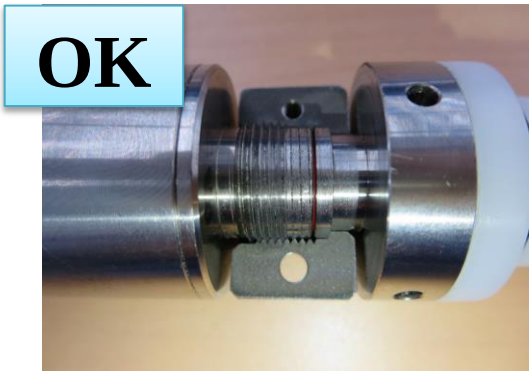
5.2 Attaching and detaching the attachment/connectors

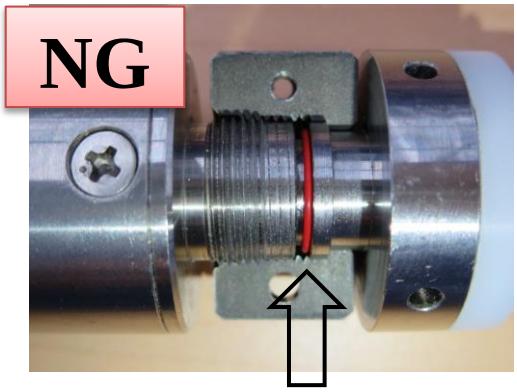
5.2.1 Standard type (ARO-FT)

(1) How to attach

Insert the connector into the main unit until two black O-rings are completely hidden. Hold it in while going to the next step.

Attach a half of the two lock-nuts, while pushing the connector and the main unit towards to each other. When you do so, make sure that the red O-ring is squashed (almost invisible) by the connector and the main unit.





Red O-ring is completely exposed.

Gap: approx. 0.5 mm

While holding them together, place two lock-nuts and temporary fix the position by using two hex-bolts (M3×10) just enough to combine two lock-nuts into one. Screw the Lock-nut tightly onto the main unit to the point you cannot turn it any more. Then, tighten the two hex bolts completely.

- Make sure that the O-rings are free of dust.
- Insert slowly so as not to warp or pinch the O-rings.
- Before use, check if the connector is inserted to the point you cannot turn it any more. Incomplete insertion can cause damage to the instrument due to the seepage of water.

(2) How to detach

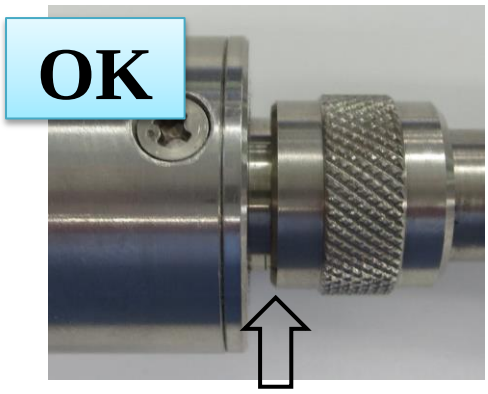
Pulling out the hex bolts disassembles the lock-nuts, then you will be able to detach.

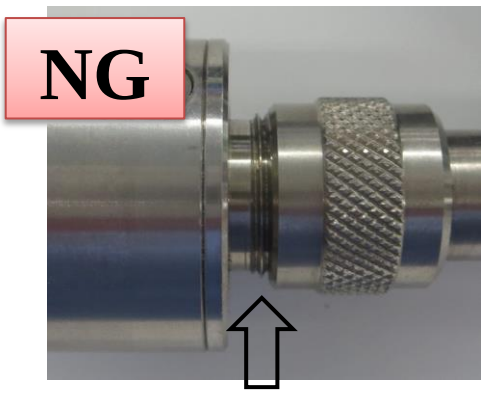
Before attaching again, apply adequate amount of grease on the O-rings.

- When detaching, hold the metal part and pull it out. Pulling only the cable can break it.

5.2.2 Cable type (ARO-FT)

(1) How to attach

<table>
<tr><td>  </td><td>Insert the connector into the main unit until two black O-rings are completely hidden. Hold it in while going to the next step.</td></tr>
<tr><td>  </td><td>Tighten the locking sleeve up to its base while pushing the connector against the main unit (see below).</td></tr>
<tr><td colspan="2">Check if the screw thread is <u>completely hidden</u>.
 

Thread is completely hidden.
 

Thread is visible.</td></tr>
</table>

- Make sure that the O-rings are free of dust.
- Insert slowly so as not to warp or pinch the O-rings.
- Before use, check if the connector is inserted up to its base. Incomplete insertion can cause damage to the instrument due to the seepage of water.

(2) How to detach

It can be pulled out by loosening the locking sleeve.

Before attaching again, apply adequate amount of grease on the O-rings.

- When detaching, hold the metal part and pull it out. Pulling only the cable can break it.

5.2.3 MCBH type (AROD-FT)

(1) How to attach

	Insert the connector into the main unit until there is no gap between.
	Tighten the locking sleeve up to its base while pushing the connector into the main unit.

- Before use, check if the connector is inserted up to its base. Incomplete insertion can cause damage to the equipment.

(2) How to detach

It can be pulled out by loosening the locking sleeve.

Before attaching again, apply adequate amount of grease on the O-rings.

- When detaching, hold the connector and pull it out. Pulling only the cable can break it.

6 Maintenance and Inspection

6.1 Before use

(1) Check that the sensor surface is free of any foreign object.

(2) Check that there is no loose or damaged connector or screw.

(3) Span/zero calibration is recommended before use.

(4) Make sure to remove the protection cap before use.

6.2 Maintenance after use

(1) After use, clean well with fresh water. If something cannot be removed by water, gently remove it with a soft cloth. Rubbing it hard can damage the oxygen detection film.

(2) After water cleaning, remove the moisture either by an air blower or by wiping with a soft cloth.

(3) Check if there is no scratch or damage on the sensor.

6.3 Storage

(1) For storing, avoid places with high temperature, high humidity, or direct sunlight.

(2) Place the sensor protection cap when storing in order to protect the sensor and prevent degradation.

(3) Avoid places with temperature higher than 40 °C as it can cause output error or degradation of the oxygen detection film.

7 Span/zero Calibration (optional)

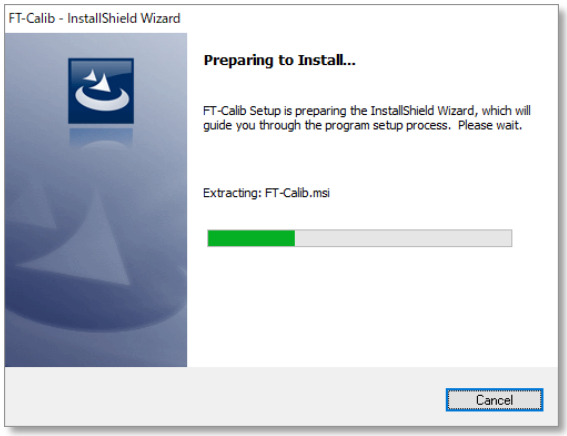
Span/zero calibration is available using the calibration kit (option).

7.1 Installation of software

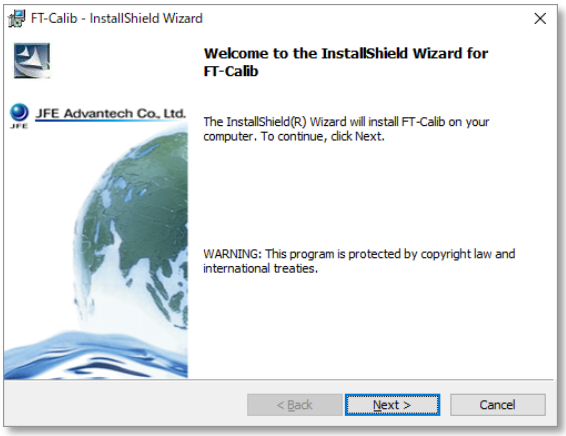
Install the RINKO FT calibration software, FT-Calib, on your PC.

(1) Insert the attached CD into the CD-ROM drive of the computer.
(2) Installation starts automatically, go to (5). If it does not start, go to (3).
(3) Open [Computer] from the start menu, and select the drive with the CD-ROM.
(4) Double-click “setup.exe”.
(5) Screens are displayed in the following order. Follow the guidance to install the software.

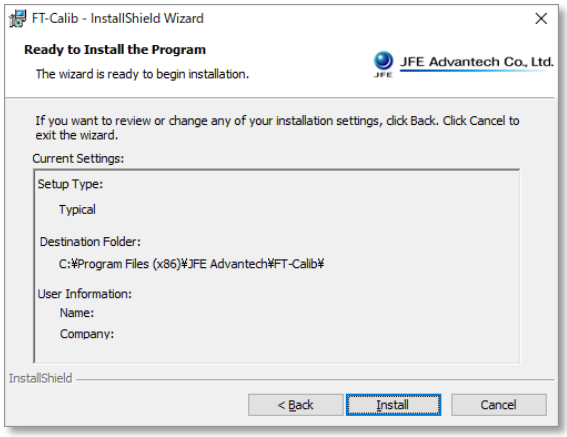
After the installation is completed, the “FT-Calib” icon appears on the desktop and in the start menu [All Programs > JFE Advantech > FT-Calib].



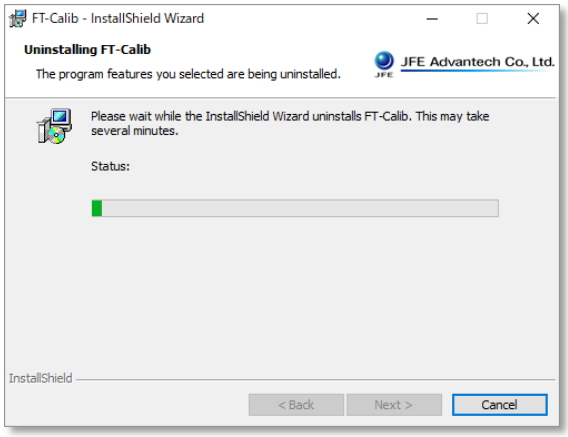
(1) Preparing to install



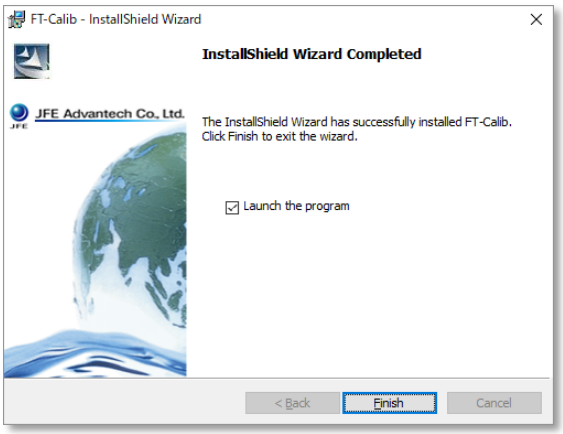
(2) [Next >]



(3) Start installation by clicking [Install].



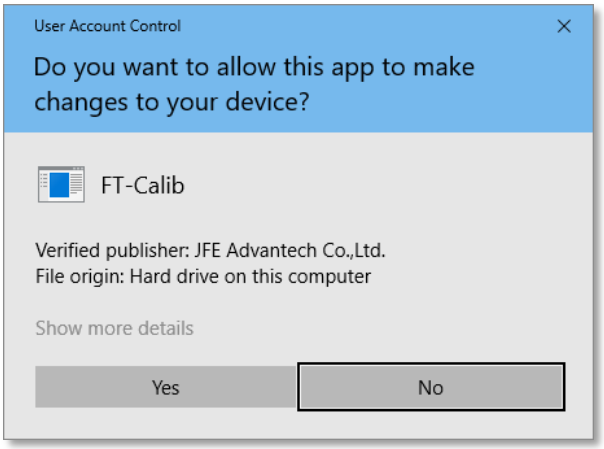
(4) Installing



(5) Complete the installation by clicking [Finish].

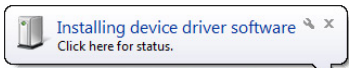
"FT-Calib" icon

- If the OS is Windows Vista or later, User Account Control (UAC) dialog may be displayed during installation for security.
- If UAC dialog appears, select [Yes] to continue the installation.
- UAC dialog might not appear depending on the computer setup, but this is not abnormal.



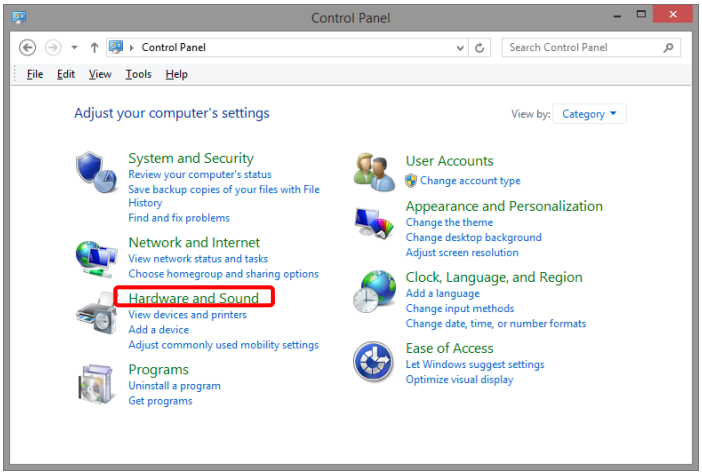
7.2 Installation of driver

(1) The screen below will be displayed if the interface is connected to the computer.

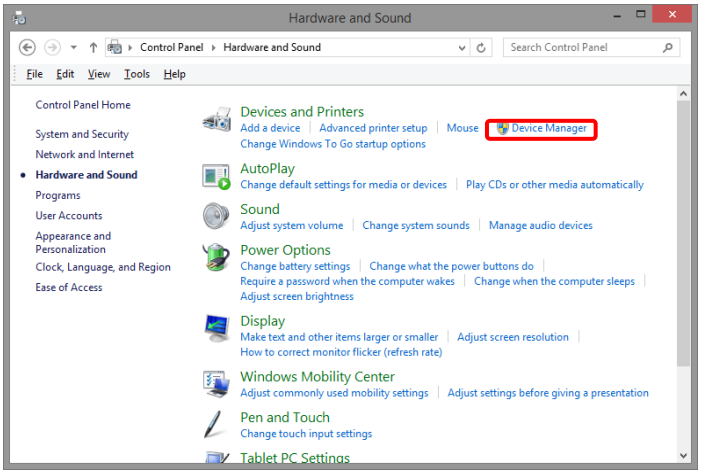


(2) The driver needs to be installed if it displays the screen below. Follow the steps below. Following procedures are not necessary if the driver is properly installed.

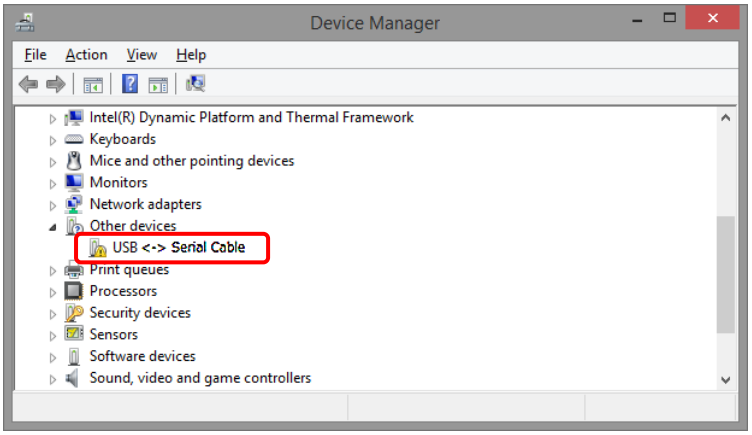
(3) Open [Control Panel] from start menu and click [Hardware and Sound].



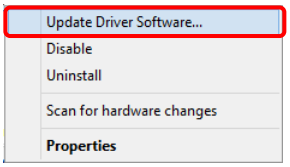
(4) Click [Device Manager].



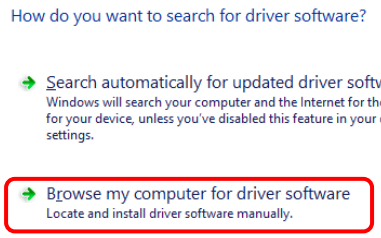
(5) If the driver cannot be installed, there will be an item with [!] mark as shown below.



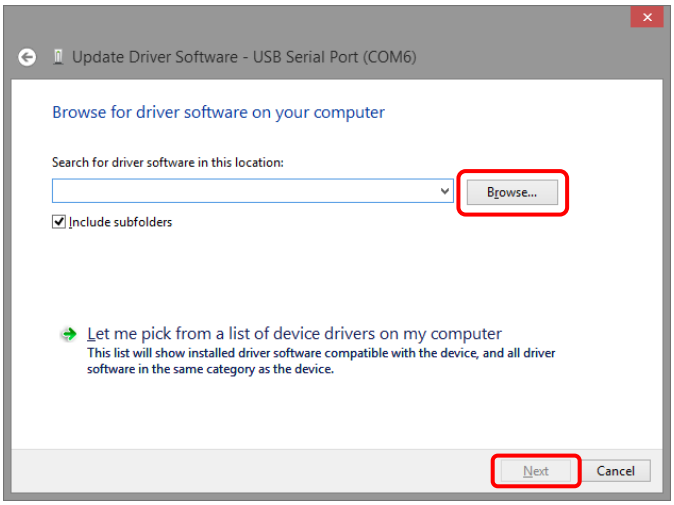
(6) Right-click the item with the [!] mark and click [Update Driver Software…]



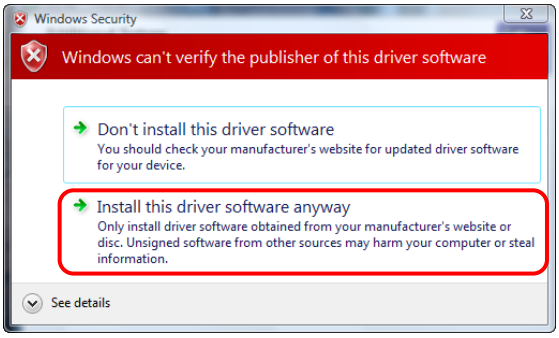
(7) Click [Browse my computer for driver software].



(8) Click [Browse…] button and select the CD-ROM or the [ARO-FT Driver] folder inside where "FT-Calib" folder was installed. After selecting, click the [Next] button.

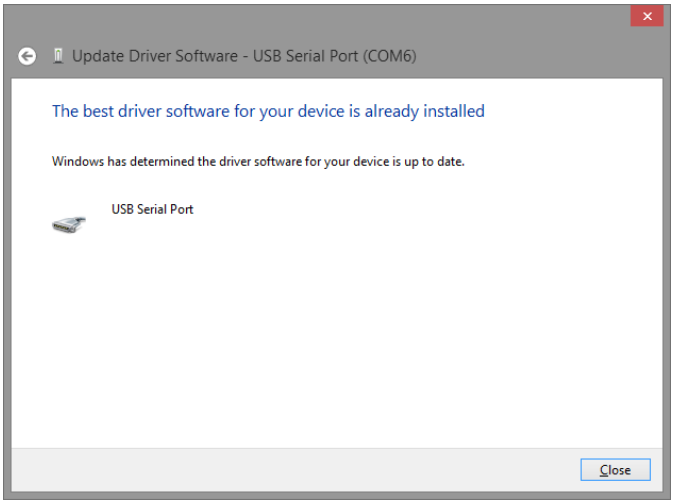


(9) If it displays the screen below, click [Install this driver software anyway].



(10) If it displays the screen below, you have succeeded with the driver installation.

Check the Device Manager to make sure that the marks such as [!] and [?] have disappeared. If the marks are still present, try the same procedure again.



7.3 How to communicate with the instrument

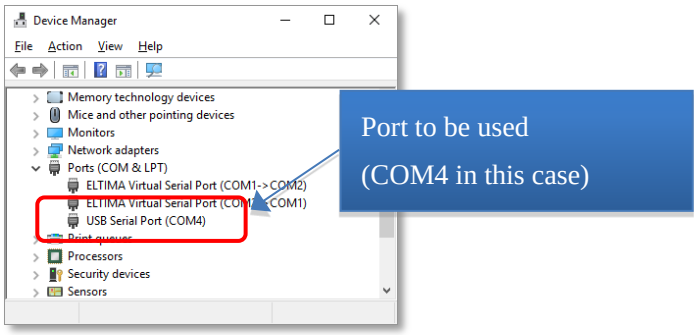
(1) Connect the instrument to the LEMO connector and connect the USB converter to the PC via USB cable.

(2) Check the Device Manager to see which port the instrument is connected to.

(a) Display Device Manager.

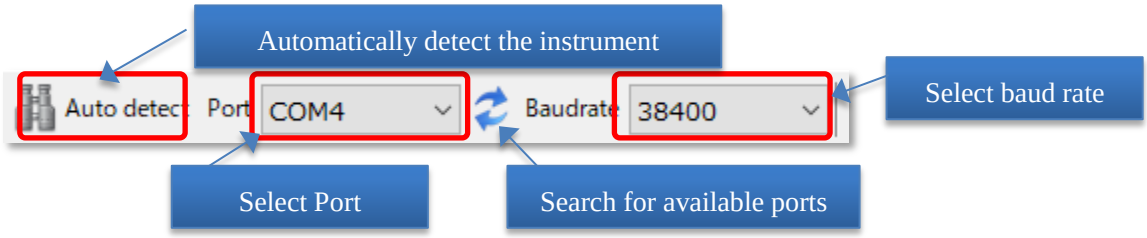
- [Start > Control Panel], [Hardware and Sound > Device Manager] (if it is "View by: Category")
- Right-click [Start > Computer] and search [Properties], [Device Manager]

(b) Check "Port (COM and LPT)".

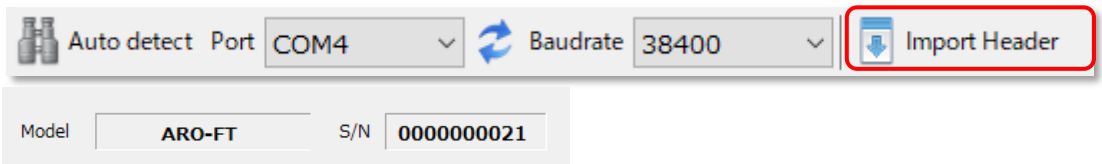


(3) Start the specialized software "FT-Calib" (see 7.4.1).

(4) Search for the instrument by clicking on [Auto detect] button. Please select the port searched by using device manager in case it cannot be searched. In case the port cannot be found, re-search for ports on your PC by clicking on [ ] button. Baud rate default is 38400.



(5) It is possible to obtain the header information and check the connection by clicking the "Receive Header" button.



7.4 How to use the software

7.4.1 Start the software

The software can be started by the following method.

(1) Start from the Start button.

(1) Select [Start > All Programs > JFE Advantech > FT-Calib > FT-Calib].

(2) The software starts.

(2) Double-click the icon on Desktop.

(1) Double-click the [FT-Calib] icon on Desktop.

(2) The software starts.

7.4.2 Close the software

The software can be closed by the following method.

(1) Close from the [File] menu.

The software closes when selecting [File > Close].

(2) Close by the [×] button on the title bar.

The software closes when clicking the [×] button.

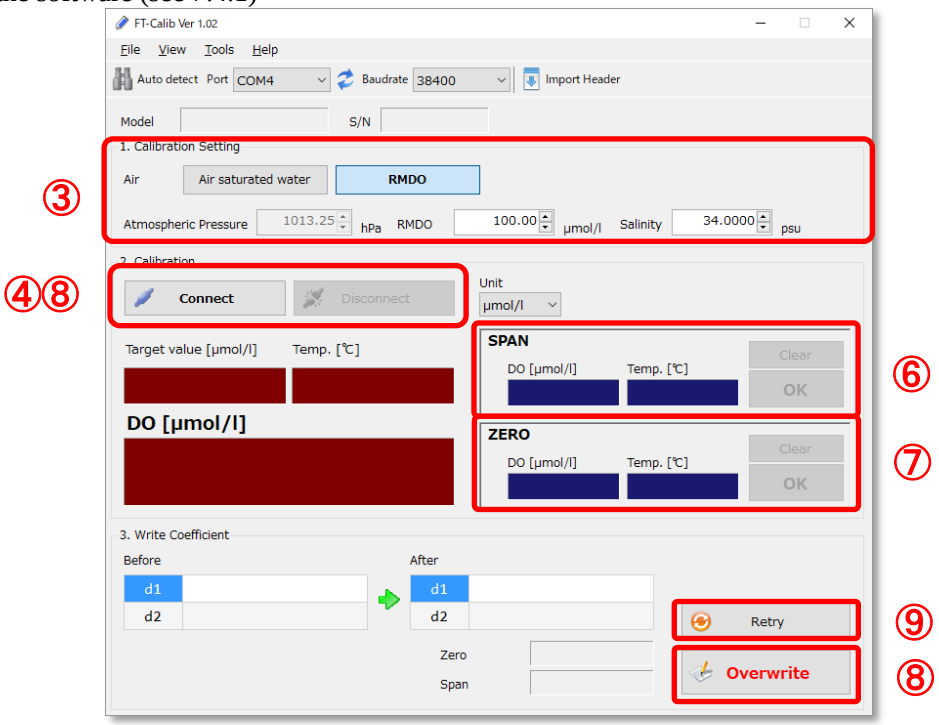
- The data in calibration process will be deleted once you close the software. Confirm that there will be no problem before closing the software.
- The software cannot be closed during communication processes. Close either after stopping the communication process or after completing the process.

7.5 How to calibrate the instrument

Calibration procedure is described below.

① Prepare the instrument and connect it to the computer.

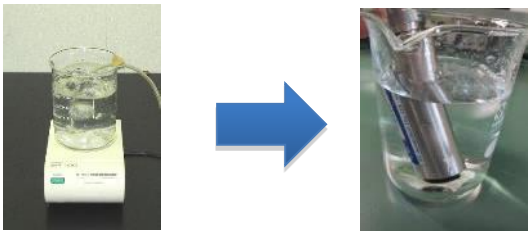
② Start the software (see 7.4.1)



③ Set calibration settings (see 7.5.3).

④ Connect to the instrument by clicking the [Connect] button.

⑤ Sparge air into water while stirring for more than 30 minutes (using a stirrer is recommended). Place the DO sensor in air-sparged water and wait until the value stabilizes.



⑥ When the value stabilizes, click the [OK] button and obtain the value. The value can be obtained as many times as desired.

⑦ Next, place the DO sensor in a sodium sulfite solution (see 7.5.2) and obtain the value in the same way. Measure while slowly turning the instrument so as not to make bubbles. Place the tip of the sensor approximately 3 cm above the bottom. Note that after pushing [OK] for the zero calibration, it is not possible to return to the span calibration.

⑧ When all the values are obtained, a new constant is calculated. After finishing the communication by clicking the [Disconnect] button, save the calibration value by clicking the [Write] button.

⑨ Delete all the values by clicking the [Retry] button and restart the calibration.

- Carry out this process with care as it affects physical quantities.
- Make sure to complete the span calibration first.
- Even if communication is stopped during calibration, it can be continued.
- Displays a warning sign if calibration was failed. Recalibrate if the warning was displayed.
- Unable to reverse once the new constant is saved.
- Consider replacing the sensor film if the value is not calibrated.

7.5.1 How to make air-sparged water for SPAN calibration

Air-sparged water (Air-saturated water)	Sparge air into 500 mL of water while stirring for more than 30 minutes.

7.5.2 How to make sodium sulfite solution for zero calibration

Make the sodium sulfite solution (referred to as Na_2SO_3 solution) for zero calibration by the below process. Please note that JFE Advantech does not provide a sodium sulfite outside of Japan.

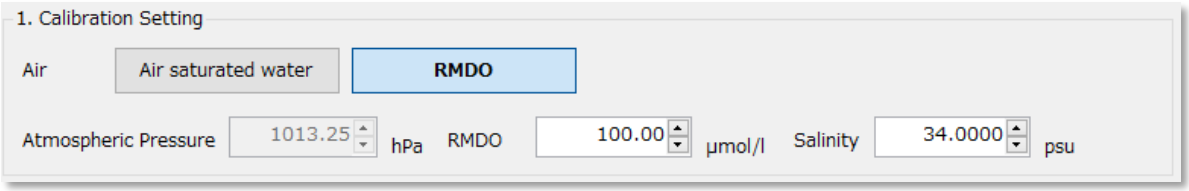
Na_2SO_3 solution	Dissolve 25 g of sodium sulfite in 500 mL of water.

Caution

- If Na_2SO_3 solution enters eyes or mouth, immediately stop the operation and apply appropriate treatment according to the Safety Data Sheet (SDS).
- If Na_2SO_3 solution touches the skin, immediately wash it off with large amount of water.
- When disposing used solutions, do so appropriately according to the SDS.

7.5.3 Calibration Setting

Note that the items for setting differ depending on the reference materials used for calibration.



Item	Description
Air saturated water	This calibration uses air-sparged water as the reference. Input [Atmospheric Pressure] at the time of calibration.
RMDO (Reference Material DO) (Under development)	A reference material can be used for calibration, which is under development as of May 2016. Input the values displayed on the label of the reference material into the [RMDO] and [Salinity].

7.6 Other functions of the software

7.6.1 Update the firmware

This updates the internal program of the instrument.

We will distribute updated files via our website or individually.

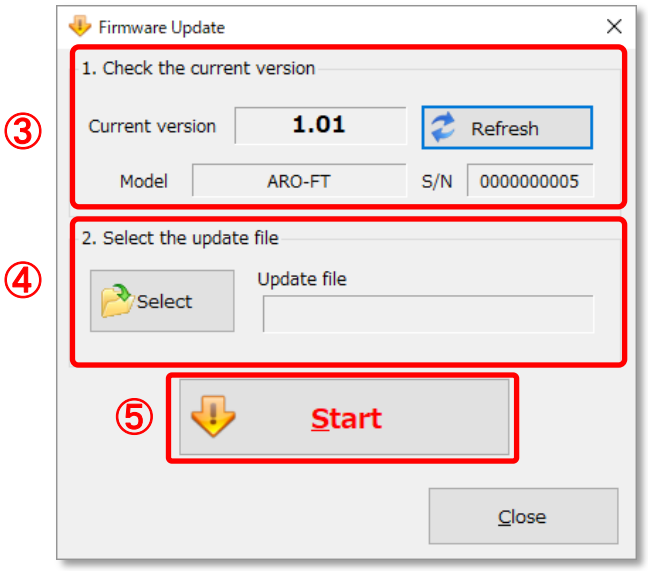
Updating takes about 5 minutes.

If the firmware update fails, the instrument will become unusable.

Update the firmware with care.

① Start the software “FT-Calib” (see 7.4.1).

② Select [Tools > Firmware Update] and open [Firmware Update].



③ Check the version. If it fails to obtain the version, it can be obtained by clicking the [Refresh] button.

④ Click the [Select] button to select the file to be updated.

⑤ After clicking the [Start] button, two confirmation screens will appear. Click the [OK] button to start the update.

⑥ Restart the instrument and check the instrument information after completing the update.

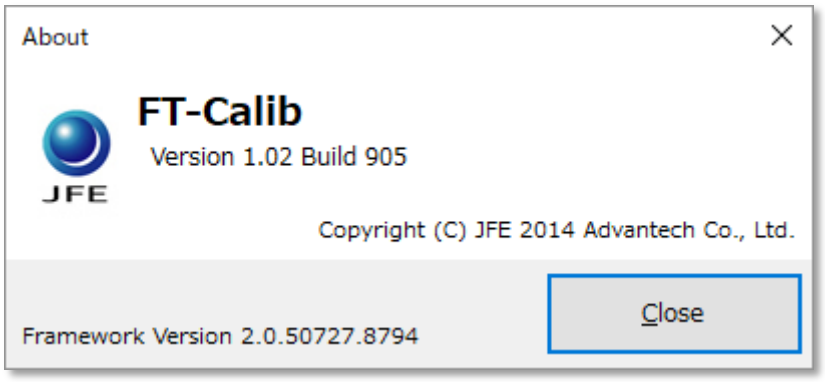
- Never turn off the power or disconnect cables during the update.
- Before updating the firmware, check the contents of our website or announcement before updating the firmware.
- If the firmware update fails, the instrument will become unusable. Update the firmware with care.
- If the update of firmware fails and the instrument is disabled, contact JFE Advantech.

7.6.2 Check the software version

The software version can be checked. When there is any problem, inform JFE Advantech about the problem and the version information.

(1) Start the software “FT-Calib” (see 7.4.1).

(2) Select [Help > Version information]. The [Version information] window will be displayed.



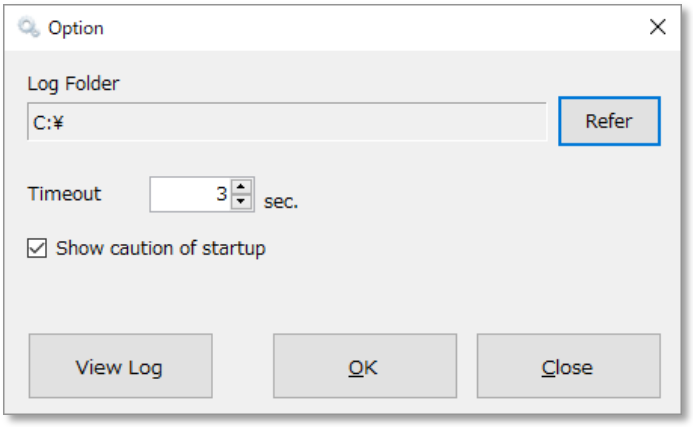
- The content and specifications may change for correction and improvement without notice.
- We try our utmost to comprehensive content, but please contact JFE Advantech for any suspicion or suggestions.
- For other handling, refer to Section 4.

7.7 Change the software settings

The settings of software's system and communication can be updated.

(1) Start the software "FT-Calib" (see 7.4.1).

(2) Select [Tools > Option]. The [Option] window will be displayed.



(3) Change the settings as needed. Display the log information with the [View log] button (see 7.7.1)

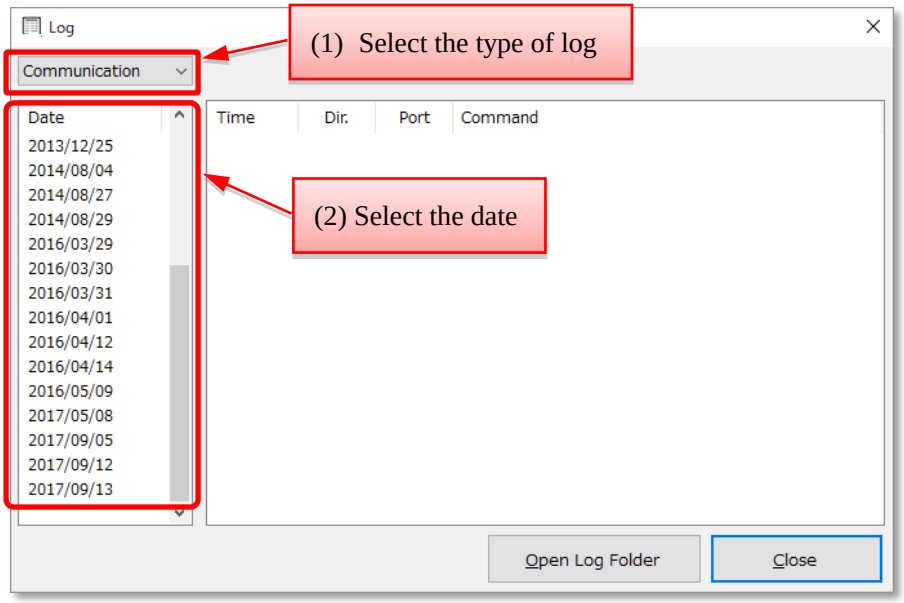
(4) Click the [OK] button to save the setting. Click the [Close] button to close without saving.

Item	Description
Log Folder	The folder where the logs of calibration and communication are saved.
Timeout	Time length of response to communication commands. If time-out occurs frequently, set this value longer (default: 3 seconds).
Show caution of startup	Shows a caution of startup (see 7.7.2) when starting the software (default: ON).

- Depending on the change in the setting, the functionality of the instrument can change significantly. Change the settings with great caution.
- Carefully examine the functionality of the instrument after changing the settings.

7.7.1 Browse the log

Logs of calibration and communication can be browsed. The log information is displayed by clicking the [View Log] button.

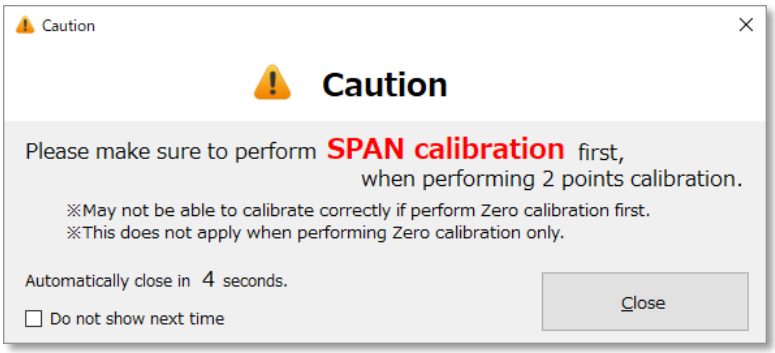


(1) After selecting the log to browse, its date of creation is displayed.

(2) After selecting the date to browse, the logs are displayed.

7.7.2 Display of precautions for calibration

A caution for calibration is displayed when starting the software. The display of the caution can be changed by Option (see 7.7).



- The display closes automatically in 5 seconds.
- If you check the [Do not show next time] box, the caution will not be displayed from the next time the software is started.
- The countdown stops when [Do not show next time] is changed.

7.8 Uninstallation of the software

The software can be uninstalled in one of two ways below.

7.8.1 Uninstall using the Start Menu

① From the Start Menu, select [All Programs > JFE Advantech > FT-Calib] and click [Uninstall].

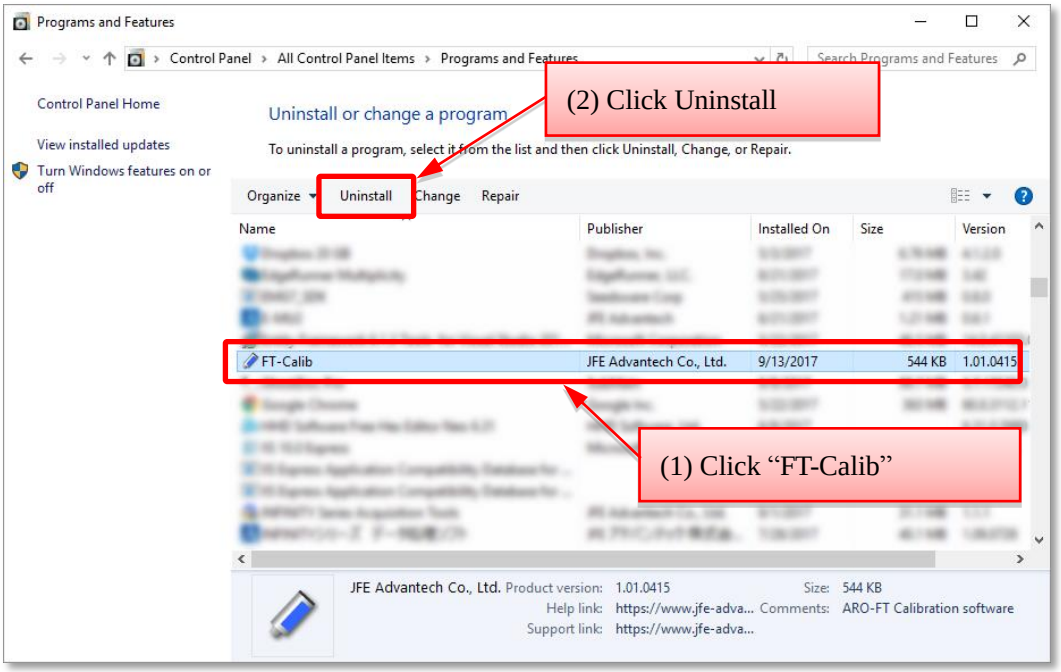
② Uninstall by following the guidance.

7.8.2 Uninstall using the Programs and Features

① From Start menu, click [Control Panel].

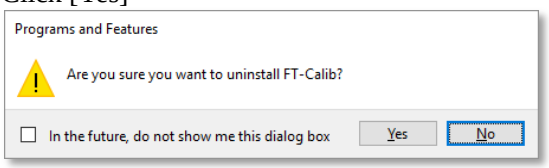
② From the [Control Panel] window, select [Programs and Features].

③ Select “FT-Calib” from the list by clicking it, and click [Uninstall] in the upper part of the window.

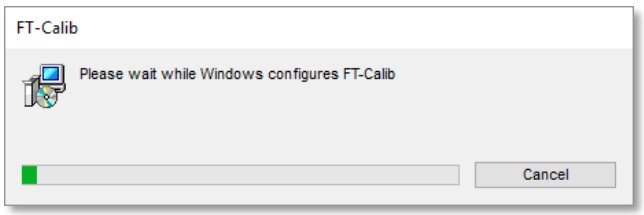


④ Screens are displayed in the following order. Uninstall according to the guidance.

(1) Click [Yes]



(2) The uninstallation is completed when the progress window closes.



8 Calculation of Physical Values

Hexadecimal AD values of temperature, DO, and LED accumulated time obtained by commands "`tdon`", "`tdona`", "`stdon`", or "`stdona`" should be converted to decimal values before the calculation of physical values. See also Chapter 8 in Appendix 1.

8.1 Temperature calculation

Temperature (T) in °C is calculated from the equation below:

$$T = A + B \times N + C \times N^2 + D \times N^3 + E \times N^4 + F \times N^5$$

T:	Temperature [°C]
A, B, C, D, E, F:	Calibration coefficients
N:	AD value of T

8.2 Oxygen calculation and compensation

The calibration for this instrument uses traceable reference gases according to the Japanese national standard. The calibration coefficients ($c_0 - c_2$, $d_0 - d_4$, and e_0) are derived from 16 calibration points (4 temperature points and 4 oxygen concentrations in freshwater). The oxygen concentration (DO) in μmol L^{-1} is calculated from the equation below:

$$DO = \left\{ \left(\frac{1 + d_0 \cdot T}{d_1 + d_2 \cdot N + d_3 \cdot t + d_4 \cdot t \cdot N} \right)^{e_0} - 1 \right\} \cdot \frac{1}{c_0 + c_1 \cdot T + c_2 \cdot T^2}$$

Uchida *et al.* (2010)

DO:	Dissolved Oxygen [μmol L^{-1}]
$c_0 - c_2, d_0 - d_4, e_0$:	Calibration coefficients
T:	Temperature [°C]
N:	(AD value of DO) / 10000
t:	LED accumulated time [s] (see Chapter 8 in Appendix 1)

The pressure-compensated oxygen concentration (DO_{pc}) in μmol L^{-1} is calculated from the equation below:

$$DO_{\mathrm{pc}} = DO\left(1 + C_p p\right)$$

p:	Pressure [MPa]
C_p:	Calibration coefficient

The salinity-compensated oxygen concentration (DO_{sc}) in µmol kg^{-1} is calculated by multiplying the factor of the effect of salt on the oxygen solubility (Benson and Krause 1984, García and Gordon 1992). The salinity & pressure-compensated oxygen concentration can be calculated by using DO_{pc} in the following equation:

$$DO_{\mathrm{sc}} = DO_{\mathrm{pc}} \exp\left[S\left(B_0 + B_1 T_s + B_2 {T_s}^2 + B_3 {T_s}^3\right) + C_0 S^2\right]$$

$$T_s = \ln\left(\frac{298.15 - T}{273.15 + T}\right)$$

T: Temperature [°C]

S: Salinity [‰ or PSU]

B_0 = - 7.01577 × 10^{-3}

B_1 = - 7.70028 × 10^{-3}

B_2 = - 1.13864 × 10^{-2}

B_3 = - 9.51519 × 10^{-3}

C_0 = - 2.75915 × 10^{-7}

The oxygen concentration is in gravimetric units (µmol kg^{-1}), and can be obtained by dividing the volumetric unit (µmol L^{-1}) by the potential density from the CTD data(making sure to convert kg m^{-3} to kg L^{-1} beforehand).

Note that the physical value output of the instrument does not consider salinity and/or pressure. The user should correct the output afterwards.

9 Troubleshooting

9.1 Main unit

Problem	Action
Unable to communicate	➔ Check if the power supply voltage is 6 – 25 VDC. ➔ Check the connectors' connection. ➔ Turn the instrument off and on again. Then try any command a few times. ➔ If RS-232C communication is used, check if the communication line is active before turning on the power of the instrument.
The measured values are unstable	➔ If something is adhered on the sensor (e.g., bio-fouling), clean it by running water or a soft cloth. See Chapter 6. ➔ Make sure that strong noise source is not in contact with the main unit or the lead wire. ➔ Check if the measurement value is obtained after the preheat time (5 seconds). ➔ Check if there is any large scratch on the oxygen detection film.

9.2 Calibration software

Problem	Action
Unable to install	● The installer does not start after inserting the CD. ➔ If the installer does not automatically start after inserting the CD, manually execute the installer file (see 7.1). ● Unable to execute the installer. The installer does not start. ➔ Check if the OS is compatible with the software (see 10.3). ➔ Check if the CD-ROM drive of your computer is functioning properly. If the problem is not with the drive but with the CD, please contact JFE Advantech.

Problem	Action
Unable to start / Slow start-up	● .NET Framework is not installed. ➔ In order for the software to function, .NET Framework 3.5 SP1 or a later version needs to be installed on the computer (see 7.1). If it is not installed, download it from Microsoft's website and install it. If your OS is Windows 7 or later, this process is usually not necessary. ● Installation is not completed properly. ➔ If installation was terminated during the process, the installation might be incomplete. If this is the case, uninstall the software first, and then reinstall it (see 7.1 and 7.8). ● Slow software start-up. ➔ Start-up can be slow depending on the specifications of the computer or .NET Framework.
Unable to communicate with the instrument	● The connection port is not set up. ➔ Set up the connection port (see 7.3). ● The connection port is wrong. ➔ If the computer has multiple ports, a port which is not connected to the instrument may be set up. Confirm the port number (see 7.3). ● Time-out occurs frequently. ➔ Set the time-out longer (see 7.7). ➔ Check if the instrument and the computer is connected properly. ● Header information is corrupted. ➔ Communication may be disabled if the header information of the instrument is corrupted. The header information needs to be fixed. Please contact us. ● Firmware update failed. ➔ If the firmware update fails, the instrument is disabled, and so is the communication. If the update of the firmware fails, please contact us.
Unable to close	● Unable to close the software by [File > Close] or the [×] button. ➔ The software cannot be closed during the recording of measured data or communication with the instrument for calibration. For logging, stop the recording of the measured data. For the calibration, disconnect the communication.

10 Specifications

10.1 Instrument specifications

Power	6 – 26 VDC (12 VDC recommended)
Current drain (at 12 VDC)	Operation mode: < 30 mA, Sleep mode: < 0.1 mA
Communication ([1])	• UART (3.3 V logic), voltage range: 3.3V ±5% (3.135 – 3.465 V) • RS-232C
Communication protocol	Baud rate: 14400, 19200, or 38400 bps (default), 8 data bits, 1 stop bit, No parity, Handshake
AD converter	16 bit digital conversion
Sampling interval	1 s
Preheat time	5 s

Note ([1]): UART (3.3 V logic) is available only for the standard type (ARO-FT).

Model name	**ARO-FT**	**AROD-FT**
Depth rating	2,000 m depth equivalent	6,700 m depth equivalent
Material	Housing: Titanium (grade 2) Insulation screw: POM	Housing: Titanium (Ti-6Al-4V)
Connector	8-pin LEMO	Impulse MCBH-8-MP or SubConn MCBH8M
Weight	In air: approx. 183 g (main unit) In water: approx. 110 g (main unit)	In air: approx. 265 g In water: approx. 175 g

10.2 Sensor specifications

Parameter	**Temperature**	**DO**
Principle	Thermistor	Phosphorescence
Measurement range	-3 – 45 °C	Oxygen concentration: 0 – 425 µmol L^{-1} ([2]) Air saturation: 0 – 200%
Calibration range	0 – 35 °C	Oxygen concentration: 0 – 255 µmol L^{-1} ([2]) Air saturation: 0 – 120%
Resolution	0.001 °C	0.01 µmol L^{-1}
Accuracy	±0.01 °C	Initial accuracy: ± 2% of measured value or ±2.0 µmol L^{-1} ([3]) Sample-based drift: < ±5% of measured value or ±5.0 µmol L^{-1} / 4,000,000 samples ([4]) Pressure effect: < ±2% of measured value or ±2.0 µmol L^{-1} ([5]) Temperature effect: < ±2% of measured value or ±2.0 µmol L^{-1}
Response time (63%)	< 1 s in water	< 1 s in water ([6])

Note ([2]): Calculated from air saturation at 25 °C and 34 PSU.
Note ([3]): Temperature calibration range: 3 – 30 °C
Note ([4]): Accelerated degradation test.
Note ([5]): Pressure hysteresis is not considered.
Note ([6]): Typical value for immersing from air-saturated water with 25 °C to sodium sulfite solution.

10.3 Software specifications

10.3.1 Recommend operational environment

Item	Specification
OS	Microsoft® Windows® XP SP3 or later (needs .NET Framework 3.5 SP1 or later) Microsoft® Windows® Vista SP2 or later (needs .NET Framework 3.5 SP1 or later) Microsoft® Windows® 7 SP1 or later (32 bit / 64 bit) Microsoft® Windows® 8 SP1 (32 bit / 64 bit) Microsoft® Windows® 10 (32bit / 64bit)
CPU	Intel Core i5 1.6 GHz or faster
Memory	Microsoft® Windows® XP: 512 MB or larger Microsoft® Windows Vista®: 1 GB or larger Microsoft® Windows® 7: 1 GB or larger (32 bit) / 2 GB or larger (64 bit) Microsoft® Windows® 8, 8.1: 1 GB or larger (32 bit) / 2 GB or larger (64 bit) Microsoft® Windows® 10: 2 GB or larger (32 bit / 64 bit)
HDD	Hard disk with space more than 1 GB (About 30 MB is needed for installation)
Resolution	1024 × 768 pixels or greater
Port	USB × 1
Other	.NET Framework 3.5 SP1 or later (only for Microsoft® Windows® XP, Windows Vista, Windows 8 later) A drive for CD-ROM (necessary for installation)

- Windows® official name is Microsoft® Windows® Operating System.
- Microsoft Windows, Windows vista / 7 / 8 / 8.1 / 10, .NET Framework are registered trademarks of Microsoft Corporation in the United States and other countries.
- Intel Core are registered trademarks of Intel Corporation in the United States and other countries.

- The software is compatible with installation to 64 bit OS but operates on 32 bit.
- Make sure the OS is updated by using Windows Update.
- .NET Framework 3.5 SP1 can be obtained from the Microsoft website.
- You will need internet access in case of installing .NET Framework 3.5 SP1 to PC with Windows 8 or later.

10.4 Drawing

Dimensions are in mm.

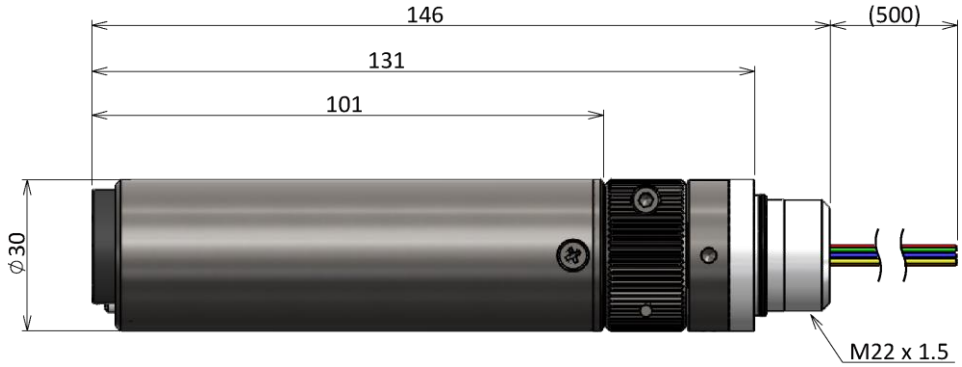


Figure 10.1 Standard type (ARO-FT)

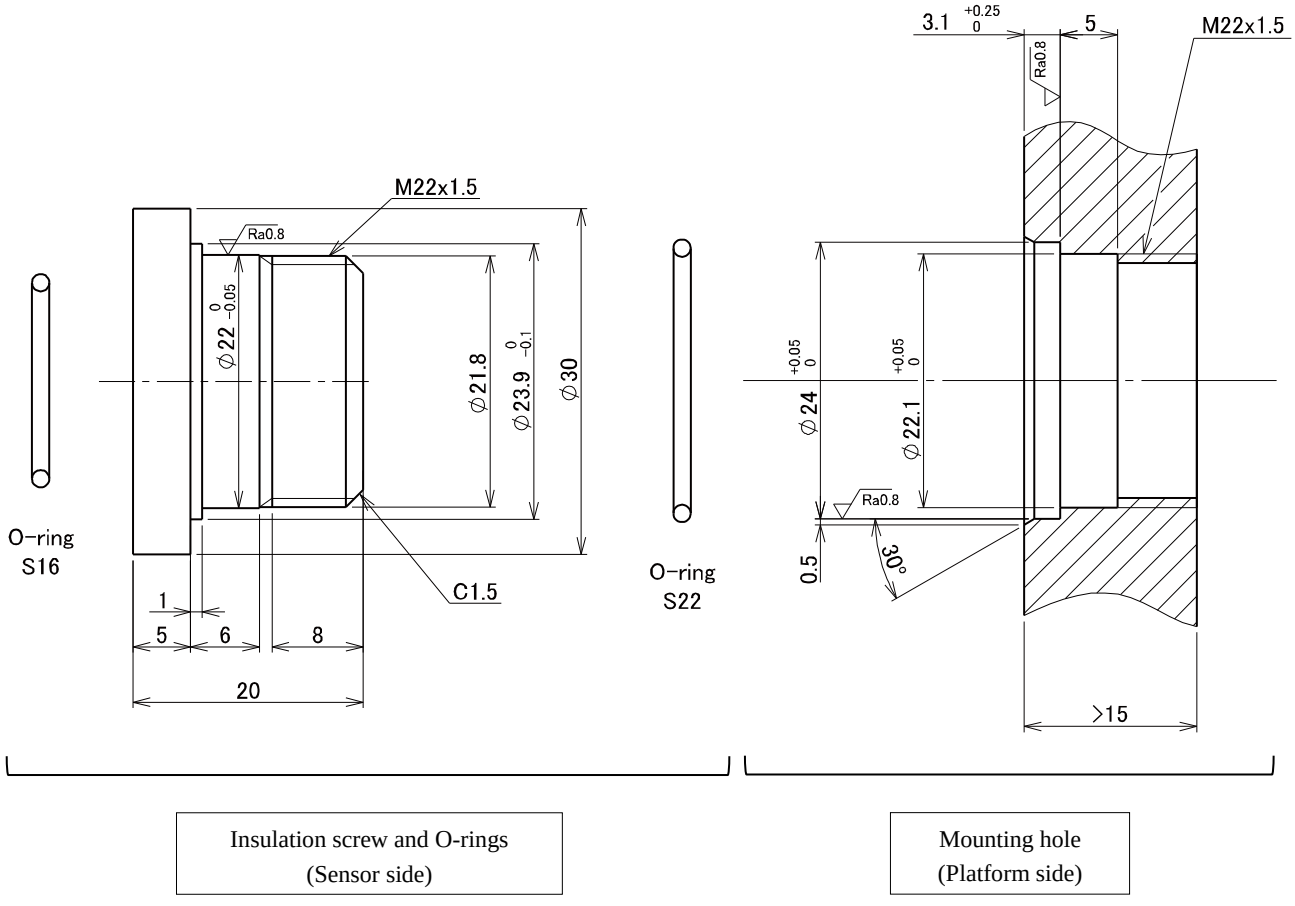


Figure 10.2 Mounting part of standard type (ARO-FT)

Dimensions are in mm.

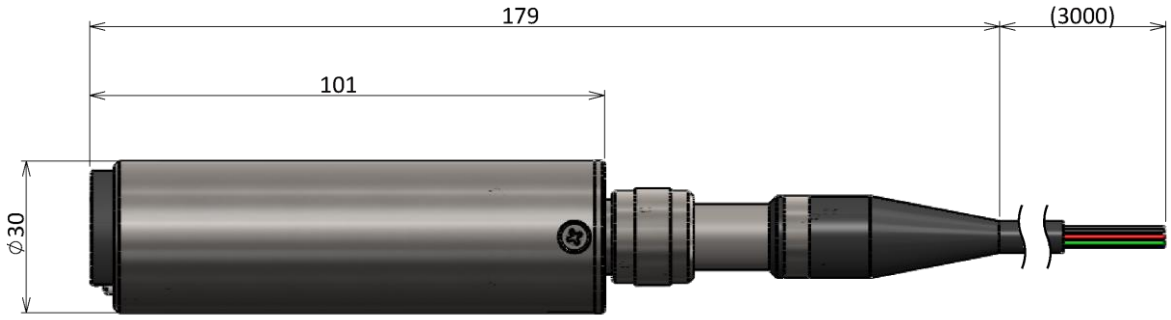


Figure 10.3 Cable type (ARO-FT)

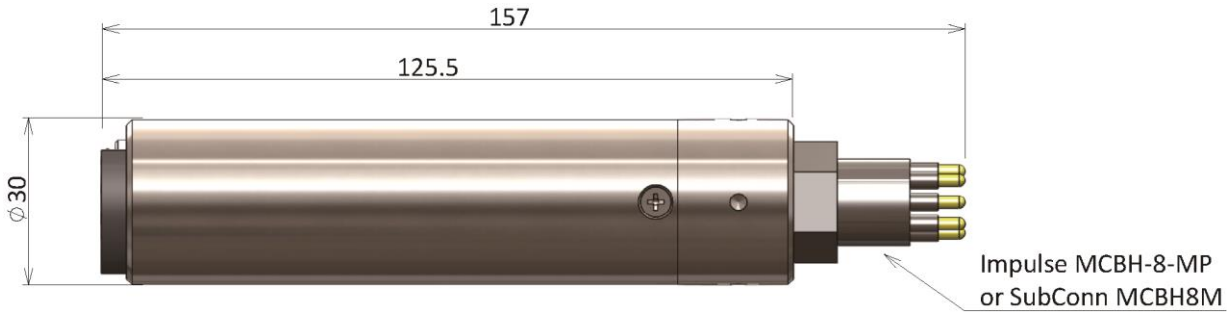


Figure 10.4 MCBH type (AROD-FT)

11 Warranty

The warranty is provided for this product.

(1) The warranty period is defined to be **1 year** after the delivery of the product. During this period, if the problem is considered to be a design or manufacturing defect, or malfunction upon a normal condition, JFE Advantech will repair the product free of charge.
(2) Scratches, stain, rust etc. on accessories, expendables, package, and exterior are out of warranty.
(3) Note that fees are applied in the cases listed below even within the warranty period.
    a. Damage during installment, mooring, and storage
    b. Malfunction and damage caused by wrong operation or carelessness
    c. Malfunction and damage caused by improper repair and modification by a third party
    d. Malfunction and damage caused by shipment, fall, and impact after purchase
    e. Malfunction and damage due to external causes such as fire, earthquake, flood, lightening, other natural disasters, public nuisance, abnormal voltage, corrosive gas, organic solvent, and chemical solution
    f. Malfunction and damage caused by abnormality in other devices connected to the product
    g. For replacing the expendables
    h. Malfunction and damage caused by replacement of the expendables done by users (e.g. O-ring and wiper blade)
    i. Malfunction and damage caused by a third party's product such as equipment and software
(4) Note that JFE Advantech will not be held liable for damage caused by the use of the product, lost profit, or any claim by a third party.
(5) Damage during installment or shipment is out of warranty. Consider obtaining insurance if such damage is of concern.
(6) In case of repair, the warranty period is defined to be **half year** after the delivery of the repaired product. During this period, if the same problem happens again upon a normal condition, JFE Advantech will repair the product free of charge.

Appendix 1: Command Reference

1 Communication Protocol

Protocol:	UART (3.3 V logic) or RS-232C **Note**: UART is available only for the standard type (ARO-FT).
Baud rate:	14400, 19200, or 38400 (default)
Data:	8 data bits
Stop bit:	1 bit
Parity:	None

2 Command Format

When sending a command from Host Controller (hereinafter, HC) to RINKO FT, it sends the command in the following format.

***Request*,*Checksum*,**<CR><LF>

When RINKO FT responds to a command from HC, it responds the command in the following format.

***Response*,*Checksum*,**<CR><LF>

Description of ***Checksum***:

The checksum is the least significant byte of ones' complement of the sum of the values of Request (or Response) and "," (comma). The checksum should be converted to 2-byte ASCII.

Example:

In case of a command "do**,*Checksum*,**<CR><LF>", 0x64 + 0x6F + 0x2C = 0xFF, then take the ones' complement of 0xFF, which equals 0x00. Then 0x00 should be converted to 2-byte ASCII, which equals "00", i.e., "do,00,<CR><LF>".

3 Sleep Mode and Precautions

a) RINKO FT has a sleep mode. In sleep mode, the RINKO FT is in the following condition.

- Analog electronics are powered OFF.
- CPU is in low-power mode.
- RINKO FT returns ***Error Code*** 0003 to the first command during the sleep mode.

  When receiving **any command** during sleep mode, the RINKO FT will send ***Error Code*** 0003 as its first ***Response*** (it will take a little time to respond in 1 second at maximum). Only the CPU will wake up (the analog electronics are still powered off) and start to appropriately accept any command. The CPU will enter low-power mode if it does not receive any command for **2 minutes**. See also Chapter 5 for ***Error Code*** 0003.

b) The DO output stabilizes 5 seconds after waking up or powering on RINKO FT (i.e., turning ON the analog power).

In order to obtain a stable and reliable DO data, it is necessary to wait at least **5 seconds** after wake-up or power-on for the first time. In this appendix, this period of time is referred to as "**preheat time**". If the analog power is already ON for more than 5 s, it should be in normal operation mode and is not necessary to wait. The state of RINKO FT can be confirmed by the command "querys". Refer to Chapter 0 for ***State***.

c) RINKO FT automatically enters sleep mode if it does not receive any command for **2 minutes**.

d) When turning off the power of RINKO FT, do so after the RINKO FT is in sleep mode if LED accumulated time is needed.

The power can be turned off immediately after receiving the "qs" response. If the Checksum does not match or the "qs" response cannot be received when sending the "qs" command in order to turn off the power, retry up to three times. After failing three times, turn off the power. We **STRONGLY RECCOMMEND** to turn off the power of RINKO FT (i.e., OFF not only analog electronics but also CPU) instead of using sleep mode.

If the RINKO FT is turned off without entering sleep mode, LED time is not accumulated appropriately. **Nothing damages** physically the RINKO FT. If LED accumulated time is not used, the RINKO FT can be turned off without entering sleep mode.

4 Commands

HC to RINKO FT	RINKO FT to HC	Description	
Request	***Response***	Outline	Detail
do	do,HEX	Send DO, enter sleep mode.	Turn ON the analog power (if it is in sleep mode), send the DO physical data [µmol/L], and enter sleep mode. If the RINKO FT analog power is OFF when receiving the command, it takes 5 seconds for the DO value to stabilize. For that reason, DO NOT USE this command during the sleep mode because the RINKO FT again enters sleep mode immediately after sending unstable/unreliable data.
tdo	tdo,HEX,HEX	Send T and DO, enter sleep mode.	Turn ON the analog power (if it is in sleep mode), send the temperature and DO physical data [°C and µmol/L], and enter sleep mode. If the RINKO FT analog power is OFF when receiving the command, it takes 5 seconds for the DO value to stabilize. For that reason, DO NOT USE this command during the sleep mode because the RINKO FT again enters sleep mode immediately after sending unstable/unreliable data. The left and right HEXs represent temperature and DO, respectively.
sdo	sdo,HEX	Send DO.	Turn ON the analog power (if it is in sleep mode) and send the DO physical data [µmol/L]. If the RINKO FT analog power is OFF when receiving the command, it takes 5 seconds for the DO value to stabilize.
stdo	stdo,HEX,HEX	Send T and DO.	Turn ON the analog power (if it is in sleep mode) and send the temperature and DO physical data [°C and µmol/L]. If the RINKO FT analog power is OFF when receiving the command, it takes 5 seconds for the DO value to stabilize. The left and right HEXs represent temperature and DO, respectively.
tdon	tdon,HEX,HEX,HEX	Send AD values of T and DO and LED time, enter sleep mode.	Turn ON the analog power (if it is in sleep mode), and send the temperature and DO AD values and LED accumulated time, and enter sleep mode. If the RINKO FT analog power is OFF when receiving the command, it takes 5 seconds for the DO value to stabilize. For that reason, DO NOT USE this command during the sleep mode because the RINKO FT again enters sleep mode immediately after sending unstable/unreliable data. The first HEX represents the temperature, the second the DO, and the third the LED accumulated time.
tdona	tdona,HEX,HEX,HEX,HEX,HEX,HEX	Send all parameters as AD values and LED time, enter sleep mode.	Turn ON the analog power (if it is in sleep mode), send temperature and DO AD values, phases of the blue and red lights (AD values), amplitudes of the blue and red lights (AD values), and LED accumulated time, and then enter sleep mode. If the RINKO FT analog power is OFF when receiving the command, it takes 5 seconds for the DO value to stabilize. For that reason, DO NOT USE this command during the sleep mode because the RINKO FT again enters sleep mode immediately after sending unstable/unreliable data. The first HEX represents the temperature, the second the DO, the third the blue phase, the fourth the red phase, the fifths the blue amplitude, the sixth the red amplitude, and the seventh the LED accumulated time.
stdon	stdon,HEX,HEX,HEX	Send AD values of T and DO and LED time.	Turn ON the analog power (if it is in sleep mode) and send the temperature and DO AD values and LED accumulated time. If the RINKO FT analog power is OFF when receiving the command, it takes 5 seconds for the DO value to stabilize. The first HEX represents the temperature, the second the DO, and the third the LED accumulated time.
stdona	stdona,HEX,HEX,HEX,HEX,HEX,HEX	Send all parameters as AD values and LED time.	Turn ON the analog power (if it is in sleep mode) and send temperature and DO AD values, phases of the blue and red lights (AD values), amplitudes of the blue and red lights (AD values), and LED accumulated time. If the RINKO FT analog power is OFF when receiving the command, it takes 5 seconds for the DO value to stabilize. The first HEX represents the temperature, the second the DO, the third the blue phase, the fourth the red phase, the fifths the blue amplitude, the sixth the red amplitude, and the seventh the LED accumulated time.

HC to RINKO FT	RINKO FT to HC	Description	
Request	***Response***	Outline	Detail
qs	qs,OK	Enter sleep mode.	Enter sleep mode after returning a response. When turning off the power of the RINKO FT, do so after the RINKO FT is in sleep mode.
*serialnumber	*serialnumber=S	Display serial number.	The serial number of the RINKO FT. "S" is an ASCII string [0-9a-zA-Z]. The length of the string is 10 at maximum.
dc	(1)dc,OK (2)***Coefficients***	Display calibration coefficients.	(1) First, it gives a response to the command (***Response***=dc,OK). (2) Next, returns the calibration ***Coefficients***. Refer to Chapter 7 for Calibration coefficients**.**
wu	wu,***State***	Wakeup.	Turn ON the analog power (if it is in sleep mode), and send current ***State*** of RINKO FT. Refer to Chapter 0 for ***State***. See also Chapters 3-a and 5 for ***Error Code*** 0003.
querys	querys,***State***	Display current state.	Send the current ***State*** of RINKO FT. Refer to Chapter 0 for ***State***.
fwver	fwver=S	Display firmware version.	Send the firmware version of RINKO FT. "S" is a string, and its format is "Ver.X.XX".
model	model=S	Display model name.	Send the model name of RINKO FT. "S" is a string. The string length is variable and maximum length is 16.
baudrate=I	baudrate=I	Set baud rate.	Set a baud rate of RINKO FT. "I" is an integer. The specified format is fixed "14400", "19200", or "38400" (default). If RINKO FT receives other than those, it responses error (Invalid parameter). New baud rate is available once RINKO FT is rebooted (i.e., power OFF and ON).
–	error=***Error Code***	Error response	Send the ***Error Code***. Refer to Chapter 5 for ***Error Code***.

Note 1: RINKO FT returns ***Error Code*** 0003 to ANY FIRST COMMAND during the sleep mode. RETRY ***Request***.

Note 2: Retry ***Request*** if there is something strange, such as no response, error response, or unmatched ***Checksum***.

5 Error Code

Error Code	Description
0001	The ***Request*** command could not be interpreted.
0002	Checksum error.
0003	First response from the sleep mode. RINKO FT returns ***Error Code*** 0003 to **any first command (even if it is "wu")** while it is in the sleep mode. After the ***Error Code*** 0003, only the CPU wakes up and starts to accept any command appropriately. Therefore, please **RESEND the same *Request***. If the RINKO FT does not receive any command for 2 minutes, the CPU will enter the low-power mode again. See also Chapter 3.
0004	Invalid parameter.

6 State of RINKO FT

State	Description
normal	RINKO FT is in normal operation mode. In this state, RINKO FT continuously measures and updates data every 1 s (but does not output/record data). When receiving a command to output data, RINKO FT outputs the latest data.
preheat	RINKO FT is in preheat state. RINKO FT is already waked up, but the sensor is preheating. In this state, measured DO is unstable and unreliable.
sleep	RINKO FT is in sleep mode. In this state, the analog electronics power is OFF and the CPU is in low-power mode. See also Chapter 3.

7 Calibration Coefficients

Coefficients	Description
C0=F	C0 coefficient (Uchida *et al.*, 2010). "F" is a real number.
C1=F	C1 coefficient (Uchida *et al.*, 2010). "F" is a real number.
C2=F	C2 coefficient (Uchida *et al.*, 2010). "F" is a real number.
d0=F	d0 coefficient (Uchida *et al.*, 2010). "F" is a real number.
d1=F	d1 coefficient (Uchida *et al.*, 2010). "F" is a real number.
d2=F	d2 coefficient (Uchida *et al.*, 2010). "F" is a real number.
d3=F	d3 coefficient (Uchida *et al.*, 2010). "F" is a real number.
d4=F	d4 coefficient (Uchida *et al.*, 2010). "F" is a real number.
Cp=F	Cp coefficient (Uchida *et al.*, 2010). "F" is a real number.
e0=F	e0 coefficient (Uchida *et al.*, 2010). "F" is a real number.
FilmNo=S	Film number "S" is an ASCII string [0-9a-zA-Z]. The length of the string is 8.
docaldate=S	Date of calibration for DO sensor. The format of "S" is "YYYY/MM/DD".
A=F	Temperature A coefficient. "F" is a real number.
B=F	Temperature B coefficient. "F" is a real number.
C=F	Temperature C coefficient. "F" is a real number.
D=F	Temperature D coefficient. "F" is a real number.
E=F	Temperature E coefficient. "F" is a real number.
F=F	Temperature F coefficient. "F" is a real number.
G=F	Temperature G coefficient. "F" is a real number.
H=F	Temperature H coefficient. "F" is a real number.
tcaldate=S	Date of calibration for temperature sensor. The format of "S" is "YYYY/MM/DD".

Example of command for calibration coefficients:

```
dc,OK,46,<CR><LF>
C0=3.24923E-03,E9,<CR><LF>
C1=1.40598E-04,E5,<CR><LF>
…
docaldate=2013/05/21,09,<CR><LF>
A=2.345,59,<CR><LF>
B=13.66666,B4,<CR><LF>
…
tcaldate=2013/05/21,68,<CR><LF>
```

8 Data Format

- HEX data format for commands "do", "tdo", "sdo", and "stdo";
  The HEX format is extracted as follows.
  - Temperature in physical value
    HEX=TTTT
    TTTT is a value for temperature and four-letter HEX value.

    $$\text{Temperature [℃]} = \frac{\text{(decimal expression for TTTT)}}{1000} - 5$$

    If temperature < -5.000, then set 0000 to TTTT.
    If temperature > 40.000, then set FFFF to TTTT.
  - DO in physical value
    HEX=DDDD
    DDDD is a value for DO and four-letter HEX value.

    $$\text{DO [μmol L}^{-1}\text{]} = \frac{\text{(decimal expression for DDDD)}}{100}$$

    If DO > 425.00, then set FFFF to DDDD.

- HEX data format for commands "tdon", "tdona", "stdon", and "stdona";
  The HEX format is extracted as follows.
  - Temperature in AD value
    HEX is between 0000 and FFFF.
    Fixed length of 4
  - DO in AD value
    HEX is between 0000 and FFFF.
    Fixed length of 4
  - LED accumulated time
    HEX is between 00000000 and FFFFFFFF.
    Fixed length of 8
    LED accumulated time is expressed by a factor of 10 ms, e.g. the decimal value "5" corresponds to 50 ms.
    LED accumulated time in seconds is calculated by the equation below:

    $$\text{LED accumulated time [s]} = \frac{\text{(decimal expression for LED accumulated time)}}{100}$$

- "I" data format
  "I" represents integer.

- "F" data format
  "F" represents real number.
  "F" is variable-length and 16 at maximum.

9 Miscellaneous

- The GND terminal for RS-232C is same with that of the power supply.
- For RS-232C connection, establish the communication line **before** turning on the power of the RINKO FT.
- For UART connection, use same GND terminal for both the RINKO FT power GND and the HC transceiver IC.
- Phase/amplitude data are utilized by the instrument to internally calculate the AD values of DO. Phase/amplitude AD values are for an easy diagnostic at factory in case of trouble.

Appendix 2: Command Summary

No.	Command	Type	Command format	Data	Data length	Check-sum	Description	Physical value		AD value						LED accumulated time	Enter sleep mode
								Temp. [°C]	DO [µmol/L]	Temp.	DO	Phase		Amplitude			
												Blue light	Red light	Blue light	Red light		
1	do	***Request***	0 1 2 3 4 5 6 7 'd' 'o' ',' *Checksum* ',' CR LF			0x00			✔								✔
2	do,HEX	***Response***	0 1 2 3 4 5 6 7 8 9 10 11 12 'd' 'o' ',' Hex=***DO*** ',' *Checksum* ',' CR LF	***DO***	4	*unfixed*	DO physical value										
3	tdo	***Request***	0 1 2 3 4 5 6 7 8 't' 'd' 'o' ',' *Checksum* ',' CR LF			0x8C		✔	✔								✔
4	tdo,HEX,HEX	***Response***	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 't' 'd' 'o' ',' Hex=***Temp*** ',' Hex=***DO*** ',' *Checksum* ',' CR LF	***Temp*** ***DO***	4 4	*unfixed*	T. physical value DO physical value										
5	sdo	***Request***	0 1 2 3 4 5 6 7 8 's' 'd' 'o' ',' *Checksum* ',' CR LF			0x8D			✔								
6	sdo,HEX	***Response***	0 1 2 3 4 5 6 7 8 9 10 11 12 13 's' 'd' 'o' ',' Hex=***DO*** ',' *Checksum* ',' CR LF	***DO***	4	*unfixed*	DO physical value										
7	stdo	***Request***	0 1 2 3 4 5 6 7 8 9 's' 't' 'd' 'o' ',' *Checksum* ',' CR LF			0x19		✔	✔								
8	stdo,HEX,HEX	***Response***	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 's' 't' 'd' 'o' ',' Hex=***Temp*** ',' Hex=***DO*** ',' *Checksum* ',' CR LF	***Temp*** ***DO***	4 4	*unfixed*	T. physical value DO physical value										
9	tdon	***Request***	0 1 2 3 4 5 6 7 8 9 't' 'd' 'o' n' ',' *Checksum* ',' CR LF			0x1E											
10	tdon,HEX, HEX,HEX	***Response***	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 't' 'd' 'o' n' ',' HEX=***Temp*** ',' HEX=***DO*** ',' 15 16 17 18 19 20 21 22 23 24 25 26 27 28 HEX=***LED*** ',' *Checksum* ',' CR LF	***Temp*** ***DO*** ***LED***	4 4 8	*unfixed*	T. AD value DO AD value LED accumulated time			✔	✔					✔	✔
11	tdona	***Request***	0 1 2 3 4 5 6 7 8 9 't' 'd' 'o' n' a' ',' *Checksum* ',' CR LF			0xBD											
12	tdona,HEX, HEX,HEX, HEX,HEX, HEX,HEX	***Response***	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 't' 'd' 'o' n' a' ',' HEX=***Temp*** ',' HEX=***DO*** ',' HEX=***Phase (B)*** ',' 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 HEX=***Phase (R)*** ',' HEX=***Amplitude(B)*** ',' HEX=***Amplitude(R)*** ',' 36 37 38 39 40 41 42 43 44 45 46 47 48 49 HEX=***LED*** ',' *Checksum* ',' CR LF	***Temp*** ***DO*** ***Phase(B)*** ***Phase(R)*** ***Amplitude(B)*** ***Amplitude(R)*** ***LED***	4 4 4 4 4 4 8	*unfixed*	T. AD value DO AD value Blue phase AD value Red phase AD value Blue amp. AD value Red amp. AD value LED accumulated time			✔	✔	✔	✔	✔	✔	✔	✔

No.	Command	Type	Command format	Data	Data length	Check-sum	Description	Physical value		AD value						LED accumulated time	Enter sleep mode
								Temp. [°C]	DO [μmol/L]	Temp.	DO	Phase		Amplitude			
												Blue light	Red light	Blue light	Red light		
13	stdon	***Request***	0 1 2 3 4 5 6 7 8 9 10 's' 't' 'd' 'o' 'n' ',' Checksum ',' CR LF			0xAB											
14	stdon,HEX, HEX,HEX	***Response***	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 's' 't' 'd' 'o' n' ',' HEX=***Temp*** ',' HEX=***DO*** ',' 16 17 18 19 20 21 22 23 24 25 26 27 28 29 HEX=***LED*** ',' Checksum ',' CR LF	***Temp*** ***DO*** ***LED***	4 4 8	*unfixed*	T. AD value DO AD value LED accumulated time			✔	✔					✔	
15	stdona	***Request***	0 1 2 3 4 5 6 7 8 9 10 11 's' 't' 'd' 'o' n' a' ',' Checksum ',' CR LF			0x4A											
16	stdona,HEX, HEX,HEX, HEX,HEX, HEX,HEX	***Response***	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 's' 't' 'd' 'o' n' a' ',' HEX=***Temp*** ',' HEX=***DO*** ',' HEX=***Phase (B)*** ',' 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 HEX=***Phase (R)*** ',' HEX=***Amplitude(B)*** ',' HEX=***Amplitude(R)*** ',' 37 38 39 40 41 42 43 44 45 46 47 48 49 50 HEX=***LED*** ',' Checksum ',' CR LF	***Temp*** ***DO*** ***Phase(B)*** ***Phase(R)*** ***Amplitude(B)*** ***Amplitude(R)*** ***LED***	4 4 4 4 4 4 8	*unfixed*	T. AD value DO AD value Blue phase AD value Red phase AD value Blue amp. AD value Red amp. AD value LED accumulated time			✔	✔	✔	✔	✔	✔	✔	
17	qs	***Request***	0 1 2 3 4 5 6 7 'q' 's' ',' Checksum ',' CR LF			0xEF											
18	qs,OK	***Response***	0 1 2 3 4 5 6 7 8 9 10 'q' 's' ',' 'O' 'K' ',' Checksum ',' CR LF			0x29											✔
19	*serialnumber	***Request***	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 '*' 's' 'e' 'r' 'i' 'a' 'l' 'n' 'u' 'm' 'b' 'e' 'r' ',' Checksum ',' CR LF			0xA0											
20	*serialnumber=S	***Response***	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 '*' 's' 'e' 'r' 'i' 'a' 'l' 'n' 'u' 'm' 'b' 'e' 'r' '=' S=***Serialnumber*** ',' 25 26 27 28 29 Checksum ',' CR LF	***Serialnumber***	Max. 10	*unfixed*	Serial number										
21	dc	***Request***	0 1 2 3 4 5 6 7 'd' 'c' ',' Checksum ',' CR LF			0x0C											
22	dc,OK	***Response***	0 1 2 3 4 5 6 7 8 9 10 'd' 'c' ',' 'O' 'K' ',' Checksum ',' CR LF			0x46											
	C0=F		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 'C' '0' '=' F=***C0 coefficient*** ',' Checksum ',' CR LF	***C0 coefficient***	Max. 16	*unfixed*	DO C0 coefficient (Uchida *et al.*, 2010)										
	C1=F		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 'C' '1' '=' F=***C1 coefficient*** ',' Checksum ',' CR LF	***C1 coefficient***	Max. 16	*unfixed*	DO C1 coefficient (Uchida *et al.*, 2010)										
	C2=F		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 'C' '2' '=' F=***C2 coefficient*** ',' Checksum ',' CR LF	***C2 coefficient***	Max. 16	*unfixed*	DO C2 coefficient (Uchida *et al.*, 2010)										
	d0=F		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 'd' '0' '=' F=***d0 coefficient*** ',' Checksum ',' CR LF	***d0 coefficient***	Max. 16	*unfixed*	DO d0 coefficient (Uchida *et al.*, 2010)										

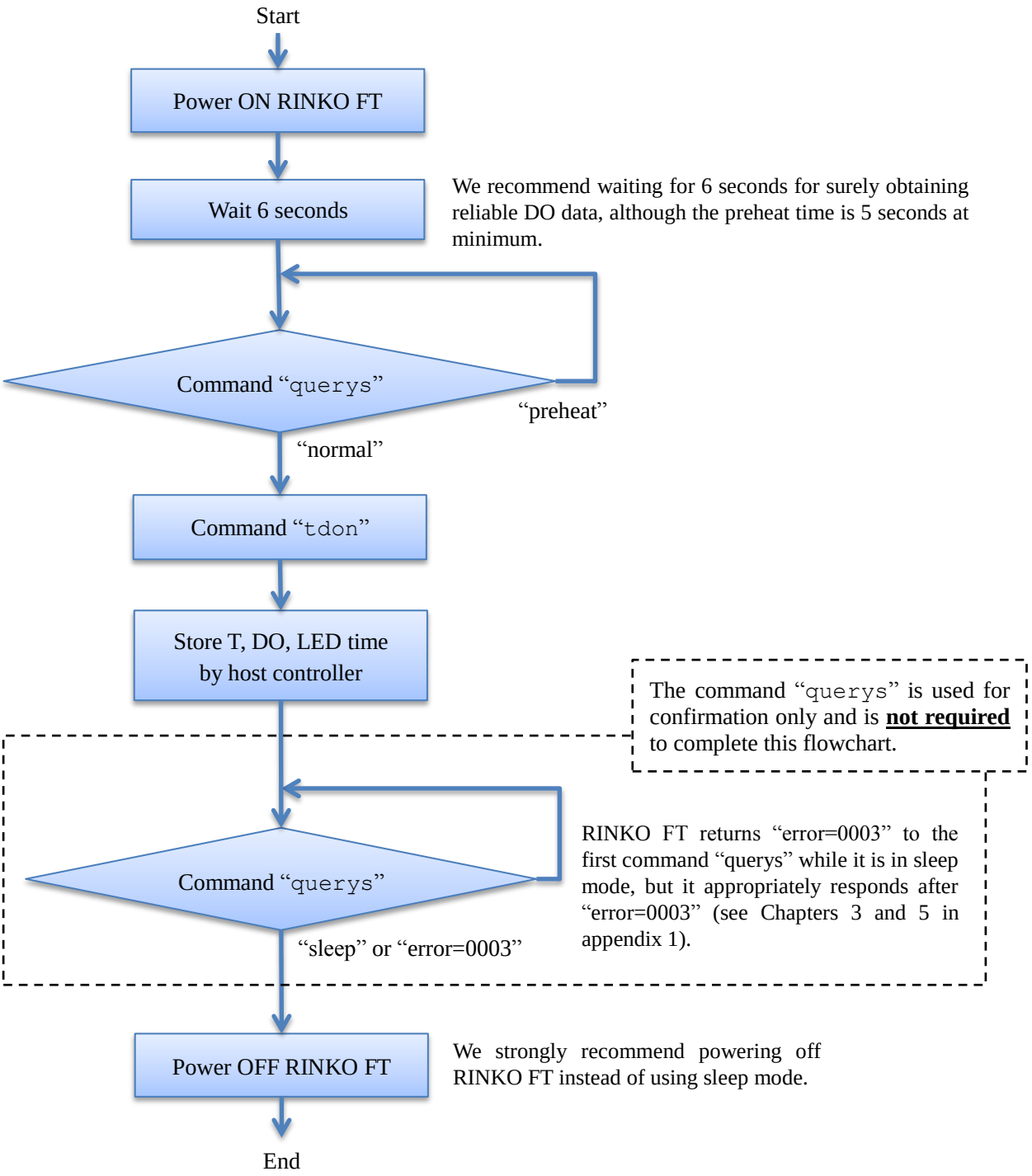
No.	Command	Type	Command format	Data	Data length	Check-sum	Description	Physical value		AD value						LED accumulated time	Enter sleep mode
								Temp. [°C]	DO [µmol/L]	Temp.	DO	Phase		Amplitude			
												Blue light	Red light	Blue light	Red light		
	d1=F		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 'd' '1' '=' F=***d1 coefficient*** ',' Checksum ',' CR LF	***d1 coefficient***	Max. 16	*unfixed*	DO d1 coefficient (Uchida *et al.*, 2010)										
	d2=F		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 'd' '2' '=' F=***d2 coefficient*** ',' Checksum ',' CR LF	***d2 coefficient***	Max. 16	*unfixed*	DO d2 coefficient (Uchida *et al.*, 2010)										
	d3=F		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 'd' '3' '=' F=***d3 coefficient*** ',' Checksum ',' CR LF	***d3 coefficient***	Max. 16	*unfixed*	DO d3 coefficient (Uchida *et al.*, 2010)										
	d4=F		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 'd' '4' '=' F=***d4 coefficient*** ',' Checksum ',' CR LF	***d4 coefficient***	Max. 16	*unfixed*	DO d4 coefficient (Uchida *et al.*, 2010)										
	Cp=F		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 'C' 'p' '=' F=***Cp coefficient*** ',' Checksum ',' CR LF	***Cp coefficient***	Max. 16	*unfixed*	DO Cp coefficient (Uchida *et al.*, 2010)										
	e0=F		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 'e' '0' '=' F=***e0 coefficient*** ',' Checksum ',' CR LF	***e0 coefficient***	Max. 16	*unfixed*	DO e0 coefficient (Uchida *et al.*, 2010)										
	FilmNo=S		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 'F' 'i' 'l' 'm' 'N' 'o' '=' S=***Film Number*** ',' Checksum ',' CR LF	***Film Number***	8	*unfixed*	Film number										
	docaldate=S		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 'd' 'o' 'c' 'a' 'l' 'd' 'a' 't' 'e' '=' S=***Calibration date*** ',' Checksum ',' CR LF	***Calibration date***	10	*unfixed*	Date of DO calib.										
	A=F		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 'A' '=' F=***A coefficient*** ',' Checksum ',' CR LF	***A coefficient***	Max. 16	*unfixed*	T. A coefficient										
	B=F		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 'B' '=' F=***B coefficient*** ',' Checksum ',' CR LF	***B coefficient***	Max. 16	*unfixed*	T. B coefficient										
	C=F		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 'C' '=' F=***C coefficient*** ',' Checksum ',' CR LF	***C coefficient***	Max. 16	*unfixed*	T. C coefficient										
	D=F		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 'D' '=' F=***D coefficient*** ',' Checksum ',' CR LF	***D coefficient***	Max. 16	*unfixed*	T. D coefficient										
	E=F		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 'E' '=' F=***E coefficient*** ',' Checksum ',' CR LF	***E coefficient***	Max. 16	*unfixed*	T. E coefficient										
	F=F		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 'F' '=' F=***F coefficient*** ',' Checksum ',' CR LF	***F coefficient***	Max. 16	*unfixed*	T. F coefficient										
	G=F		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 'G' '=' F=***G coefficient*** ',' Checksum ',' CR LF	***G coefficient***	Max. 16	*unfixed*	T. G coefficient										
	H=F		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 'H' '=' F=***H coefficient*** ',' Checksum ',' CR LF	***H coefficient***	Max. 16	*unfixed*	T. H coefficient										
	tcaldate=S		0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 't' 'c' 'a' 'l' 'd' 'a' 't' 'e' '=' S=***Calibration date*** ',' Checksum ',' CR LF	***Calibration date***	10	*unfixed*	Date of T. calib.										

No.	Command	Type	Command format	Data	Data length	Check-sum	Description	Physical value		AD value						LED accumulated time	Enter sleep mode
								Temp. [°C]	DO [μmol/L]	Temp.	DO	Phase		Amplitude			
												Blue light	Red light	Blue light	Red light		
23	wu	***Request***	0 1 2 3 4 5 6 7 'w' 'u' ',' *Checksum* ',' CR LF			0xE7											
24	wu,***State***	***Response***	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 'w' 'u' ',' 'n' 'o' 'r' 'm' 'a' 'l' ',' *Checksum* ',' CR LF ***State*** ="normal"			0x32											
			0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 'w' 'u' ',' 'p' 'r' 'e' 'h' 'e' 'a' 't' ',' *Checksum* ',' CR LF ***State*** ="preheat"			0xD2											
			0 1 2 3 4 5 6 7 8 9 10 11 12 13 'w' 'u' ',' 's' 'l' 'e' 'e' 'p' ',' *Checksum* ',' CR LF ***State*** ="sleep"			0xA2											
25	querys	***Request***	0 1 2 3 4 5 6 7 8 9 10 11 'q' 'u' 'e' 'r' 'y' 's' ',' *Checksum* ',' CR LF			0x2A											
26	querys,***State***	***Response***	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 'q' 'u' 'e' 'r' 'y' 's' ',' 'n' 'o' 'r' 'm' 'a' 'l' ',' *Checksum* ',' CR LF ***State*** ="normal"			0x75											
			0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 'q' 'u' 'e' 'r' 'y' 's' ',' 'p' 'r' 'e' 'h' 'e' 'a' 't' ',' *Checksum* ',' CR LF ***State*** ="preheat"			0x15											
			0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 'q' 'u' 'e' 'r' 'y' 's' ',' 's' 'l' 'e' 'e' 'p' ',' *Checksum* ',' CR LF ***State*** ="sleep"			0xE5											
27	fwver	***Request***	0 1 2 3 4 5 6 7 8 9 10 'f' 'w' 'v' 'e' 'r' ',' *Checksum* ',' CR LF			0xA9											
28	fwver=S	***Response***	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 'f' 'w' 'v' 'e' 'r' '=' S=***Firmware version*** ',' *Checksum* ',' CR LF	***Firmware version***	8	*unfixed*	Firmware version										
29	model	***Request***	0 1 2 3 4 5 6 7 8 9 10 'm' 'o' 'd' 'e' 'l' ',' *Checksum* ',' CR LF			0xC2											
30	model=S	***Response***	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 'm' 'o' 'd' 'e' 'l' '=' 'A' 'R' 'O' '-' 'F' 'T' ',' *Checksum* ',' CR LF S="ARO-FT"		Max. 16	0xDC	Model name										
			0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 'm' 'o' 'd' 'e' 'l' '=' 'A' 'R' 'O' 'D' '-' 'F' 'T' ',' *Checksum* ',' CR LF S="AROD-FT"			0x98											
31	boudrate=I	***Request***	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 'b' 'a' 'u' 'd' 'r' 'a' 't' 'e' '=' '1' '4' '4' '0' '0' ',' *Checksum* ',' CR LF baudrate="14400"			0x55	Set baud rate (default: 38400)										
			0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 'b' 'a' 'u' 'd' 'r' 'a' 't' 'e' '=' '1' '9' '2' '0' '0' ',' *Checksum* ',' CR LF baudrate="19200"			0x52											
			0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 'b' 'a' 'u' 'd' 'r' 'a' 't' 'e' '=' '3' '8' '4' '0' '0' ',' *Checksum* ',' CR LF baudrate="38400"			0x4F											
32	boudrate=I	***Response***	Same as ***Request***														
33	error	***Response***	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 'e' 'r' 'r' 'o' 'r' '=' I=***Error Code*** ',' *Checksum* ',' CR LF	***Error Code***	4	*unfixed*	Error code										

Appendix 3: Examples of Operation Sequence

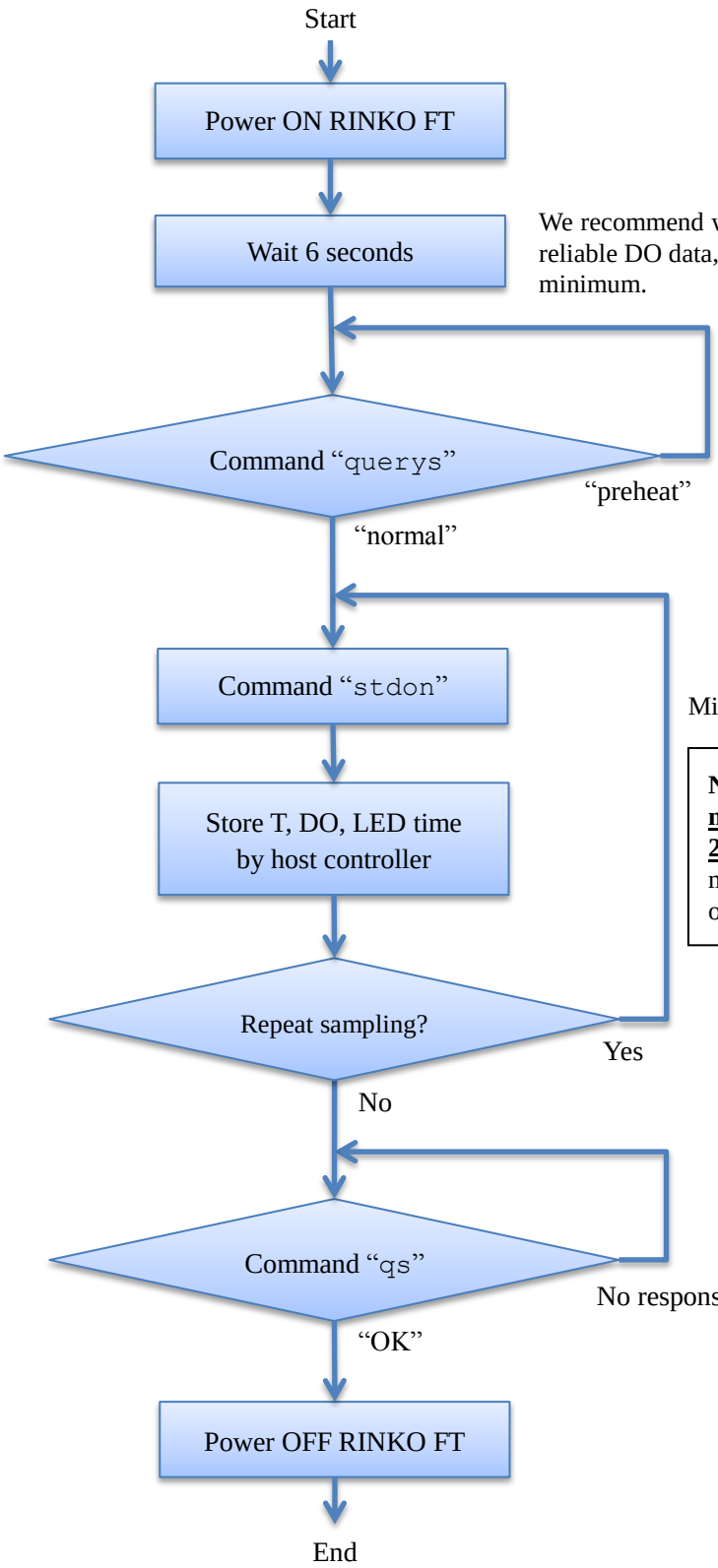
Example 1: Sample T and DO at 10 s (or more) of sampling interval.

It is much better to power on and off RINKO FT for each measurement to save energy. In other words, please repeat the flowchart below during the observation. It may take at least 7 – 8 s for single iteration, which depends on the host controller.



Example 2: Sample T and DO at 6 s (or less) of sampling interval.

In this case, RINKO FT is necessary to be continuously powered on until the observation is finished as shown in the flowchart below.



We recommend waiting for 6 seconds for surely obtaining reliable DO data, although the preheat time is 5 seconds at minimum.

Minimum sampling interval is 1s.

Note: RINKO FT automatically enters **sleep mode** if it does not receive any command for **2 minutes**. Once RINKO FT entered sleep mode, it requires 5 seconds to stabilize the DO output after waking up. See chapter 3.

取A-0133-05

Manufacturer

JFE Advantech Co., Ltd.

3-48 Takahata-cho, Nishinomiya, Hyogo, 663-8202 Japan

Phone: +81-798-66-1783 Fax: +81-798-66-1654

URL: http://www.jfe-advantech.co.jp/ E-mail: ocean@jfe-advantech.co.jp