Operating manual

Wiper-type HAI sensor
(Harmful Algal Indication Sensor)
Model：AHIW2A-CAD（RS-485）

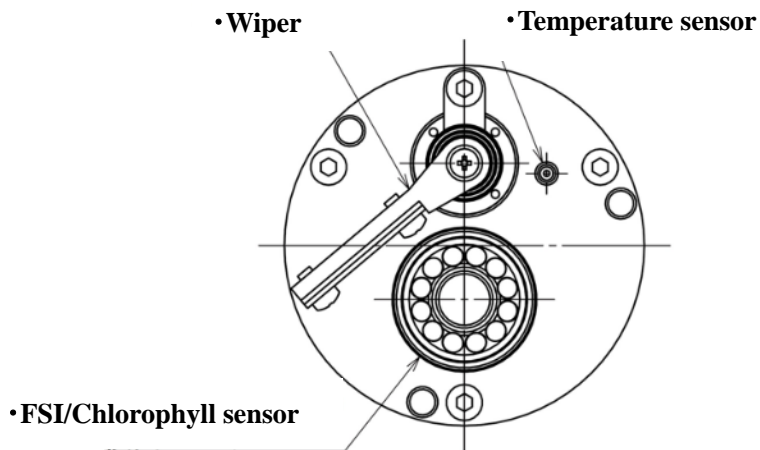| For the safe use of this |
|---|
| ● Use after thoroughly reading the operation manual.
Improper handling may lead to an accident.
● Safely keep this manual in order not to lose it. |

JFE Advantech Co., Ltd.

Introduction

- The AHIW2A-CAD can measure temperature, chlorophyll and FSI
- FSI（Fluorescence spectral shift Index） is the reference value of expressing fluorescence spectrum shift. It is calculated by the ratio of fluorescence intensity between 670nm wavelength band and 690 n m wavelength band in fluorescence spectrum.
- The AHIW2A-CAD can help detecting harmful phytoplankton causing red tides (Karenia mikimotoi and Chattonella antiqua) at early stage.
- Communication: RS-485
- The AHIW2A-CAD has a wiper function to prevent fouling. It is suitable for long term deployment.

Contents

1 Sensor and part name

1.1 Sensor diagram

・Wiper   ・Temperature sensor

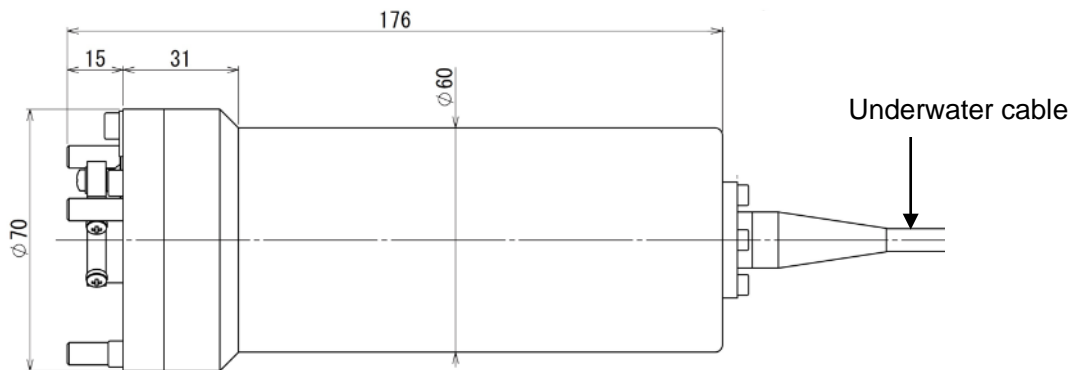・FSI/Chlorophyll sensor

1.2 External diagram

（a）Detachable cable version

176

15 31

ϕ 60

ϕ 70

Cable joint connection

（b）Fixed cable version

176

15 31

ϕ 60

ϕ 70

Underwater cable
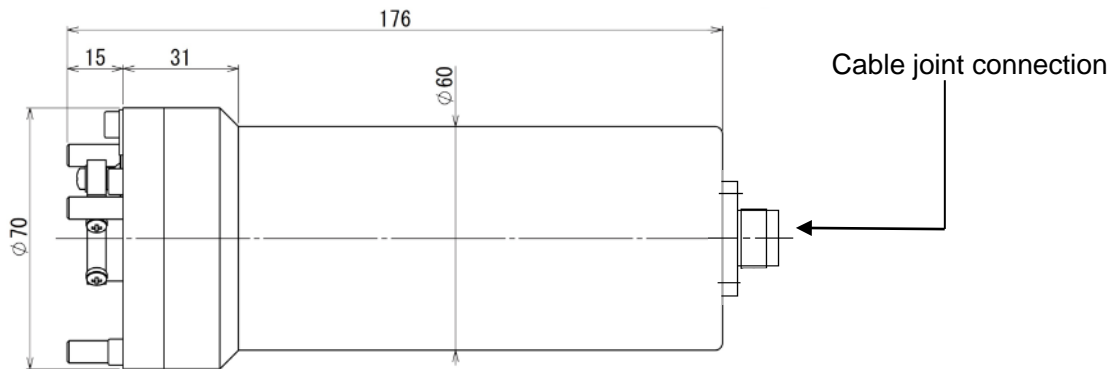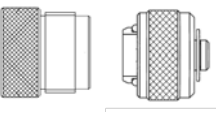
2 Packing list

2.1 AHIW2A-CAD packing list ([1])

No.	Name	Appearance ([2])	Q'ty	No.	Name	Appearance ([2])	Q'ty
1	Main unit		1	**4**	Manual		1
2	Cable		1	**5**	Silicone grease		1
3	Calibration sheet	試験成績書	1	**6**	Connector Cap		1 組

([1])　This list is the standard package. The contents may differ according to customer requests.

([2])　Contents design may differ.

・Combination of cable and connector

(a) Detachable cable version

Waterproof circular 6-pin connector（optional）

4-core unbraided

(b) Fixed cable version

Waterproof circular 6-pin connector（optional）

4-core unbraided
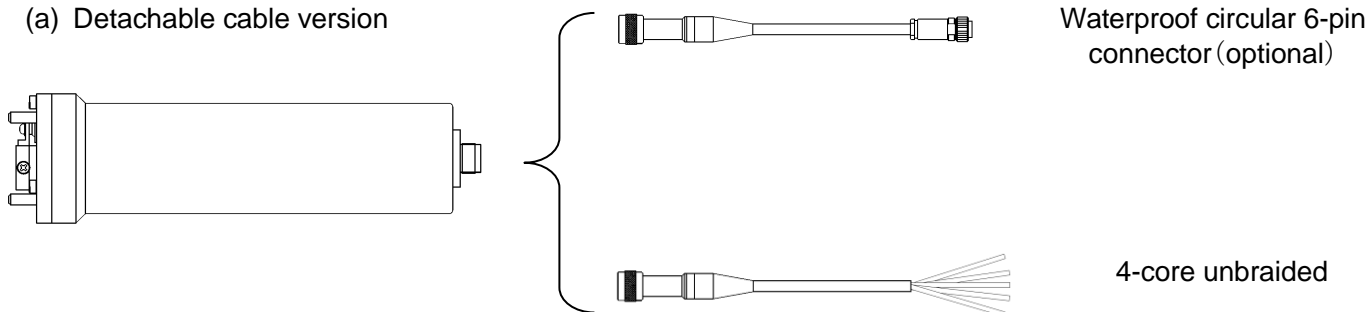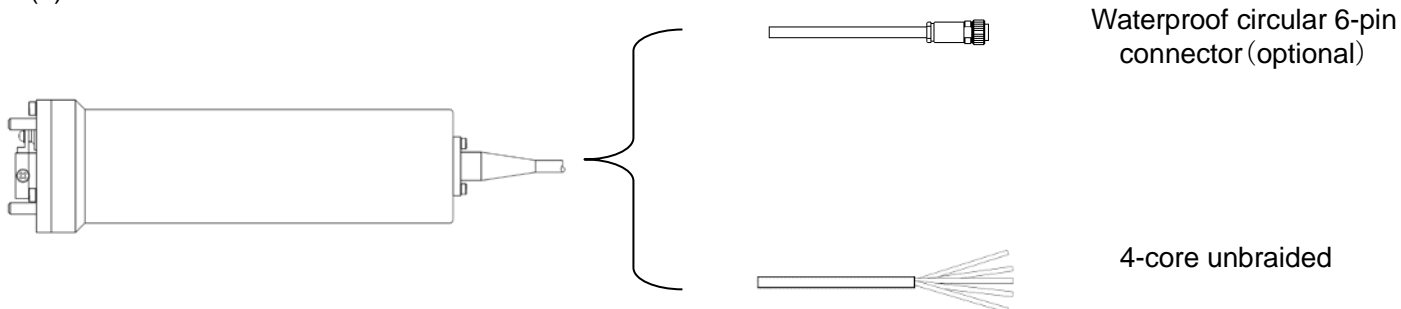
3 Safety warning

Please read before using the instrument

⚠️ **Danger**	If you handle it incorrectly, the user is likely to be at risk of death or serious injury.
⚠️ **Warning**	If you handle it incorrectly, the user may be minor or seriously injured.
⚠️ **Caution**	If you handle it incorrectly, the instrument may be damaged and unrepairable.
❗	General precautions
✅	Supplements to control method and convenient functions

3.1 How to treat the instrument

⚠️Danger

- When working at on water or on board vessels, please ensure the working environment is safe.
- Do not see the FSI/Chlorophyll sensor directly when power is supplied. It might damage eyes.

⚠️Warning

- Do not repair or disassemble anything beyond of what is written in this manual.
- Do not use the power supply exceeding the rating.
- Do not damage the cables and connectors and do not use damaged or rusted cables. Make sure that are no loose cables and connectors.
- Do not connect or disconnect cables with wet hands. It may cause an electrical shock.
- Be careful not to injure your back when you are installing or retrieving the instrument.
- Wear gloves while fixing the instrument in a wire or mooring to avoid being hurt by any burrs or ridges.

⚠️Caution

- Do not touch the wiper when it is operating.
- Do not drop the instrument or add it to the impact.
- Touch grounded metal objects, before touching the instrument to avoid any static electricity discharges.
- Do not use the damaged or rusted cable.
- Make sure not to supply power with reverse-polarity.
- If the product has not been used for a long time, do the inspection of each parts before using.
- Do not use the instrument in freezing places although the temperature range is -3 to 45℃.
- Accurate measurement cannot be done if there are some obstacles or light-emitting objects in front of the optical sensor.
- The chlorophyll sensor is calibrated with uranine reference and the physical unit is ppb.
- When the instrument is wet, it may become slippery. Be careful when handling it.
- Be careful not to touch cables and instruments on other obstacles during deployment

3.2 Maintenance

⚠️Caution

- Please gently wipe it off with soft cloth.
- Do not store the instrument in direct sunlight, in places with temperature exceeding 30℃ and in humid or dusty places.
- When disposing of this product, do so in the appropriate manner following all laws and regulations.

4 Note on use

4.1 How to use the instrument

(1) When deployed, the sunlight is removed by signal processing in the instrument, but it is better that sunlight does not enter the sensor receiving part. Therefore, direct the FSI/Chlorophyll sensor facing downward or incline it downward.

(2) When putting the instrument in water, shake the sensor to remove air bubbles. The FSI/Chlorophyll sensor cannot measure data accurately if air bubbles are adhered to it.

(3) Be careful not to touch cables and the instrument on other obstacles during deployment.

(4) Please remove contaminations on the sensor surface carefully. If there are scratches or dirt on the sensor surface, it might influence the measured data.

(5) Be careful not to apply force to wiper. There is a risk of causing the wiper malfunction

(6) Replace the wiper rubber regularly

(7) Be careful not to apply force to the water temperature sensor. There is a risk of it becoming unable to take measurements because of deformation or wire break.

(8) Pay attention not to allow moisture inside the joint point when attach and detach the underwater connector. There is a risk that the instrument becomes unable to communicate

(9) The depth for deploying HAI sensor need to take consideration of the dynamics of species of the plankton and any influence on photosynthesis from changes in solar radiation.

(10) When deploying in an estuary, due to the possibilities of inflorescence from river, FSI value may be becoming high with the effect of plankton coming from river.

(11) If harmful plankton is mixed with other plankton such as diatoms and it is not the dominant species, it may not be detected correctly when using the FSI threshold.
Refer to the condition for detection
e.g) Karenia mikimotoi

Situation of harmful plankton

Case ①	Case①	Case①	Case②	Case②, ③	Case①
Diatoms	Diatoms	Harmful plankton (more than 50cells/mℓ)	Diatoms	Diatoms	Diatoms
Harmful plankton (less than 50cells/mℓ)	Harmful plankton (more than 50cells/mℓ)		Harmful plankton (more than 50cells/mℓ)	Harmful plankton (less than 50cells/mℓ)	Harmful plankton (less than 50cells/mℓ)
△	○	○	○	✗	△
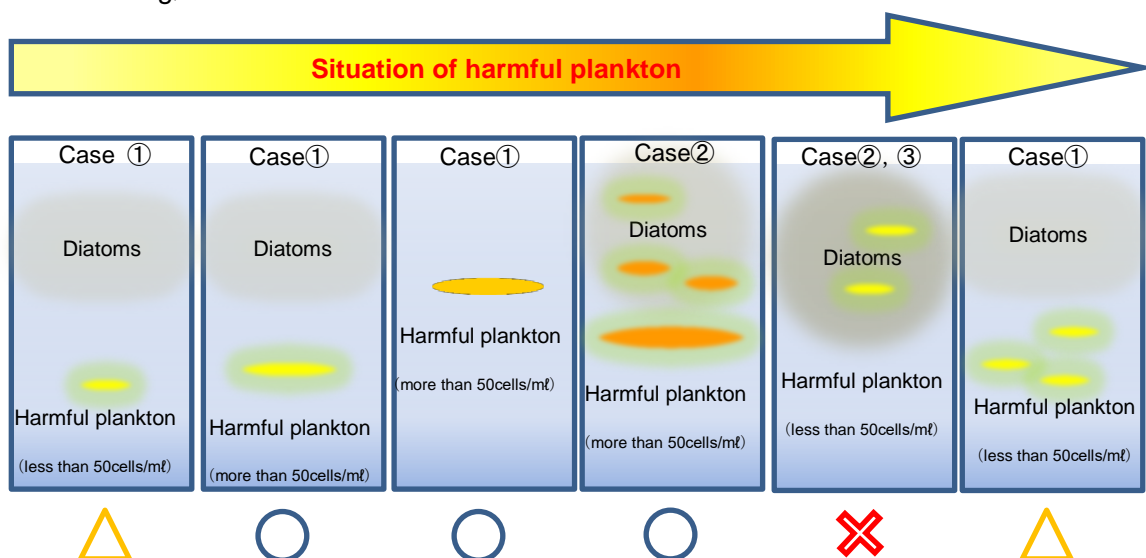
・Criterion for detaction on Karenia *mikimotoi* when using FSI threshold

Case	Dominant rate (Chl-a flourescence standard)	Cell number density Less than 50cells/ml	Cell number density More than 50cells/ml
①	Single species	△	○
②	Karenia＞Diatoms More than 50%	×	○
③	Karenia＜Diatoms Less than 50%	×	×

Criterion for detaction on Chattonella *antiqua* when using FSI threshold

Case	Dominant rate (Chl-a flourescence standard)	Cell number density Less than 10cells/ml	Cell number density More than 10cells/ml
④	Single species	△	○
⑤	Chattonella＞Diatoms More than 80%	×	○
⑥	Chattonella＜Diatoms Less than 80%	×	×

5 Connection outline

5.1 Instrument outline

（1） Waterproof circular 6-pin connector.

The sensor can be connected to our AAQ interface (optional and sold separately).

AC adapter

DC12V

Waterproof circular
6-pin connector

SENSOR   RS-485

Interface (AAQ-IF)

Detachable cable version

Fixed cable version

(2) 4-core unbraided

+POW	Red: +POW	DC12 to 24V
GND	Green: GND	
485-A	Black: 485-A	RS-485
485-B	White: 485-B	

Labeled mark

Detachable cable version

Fixed cable version
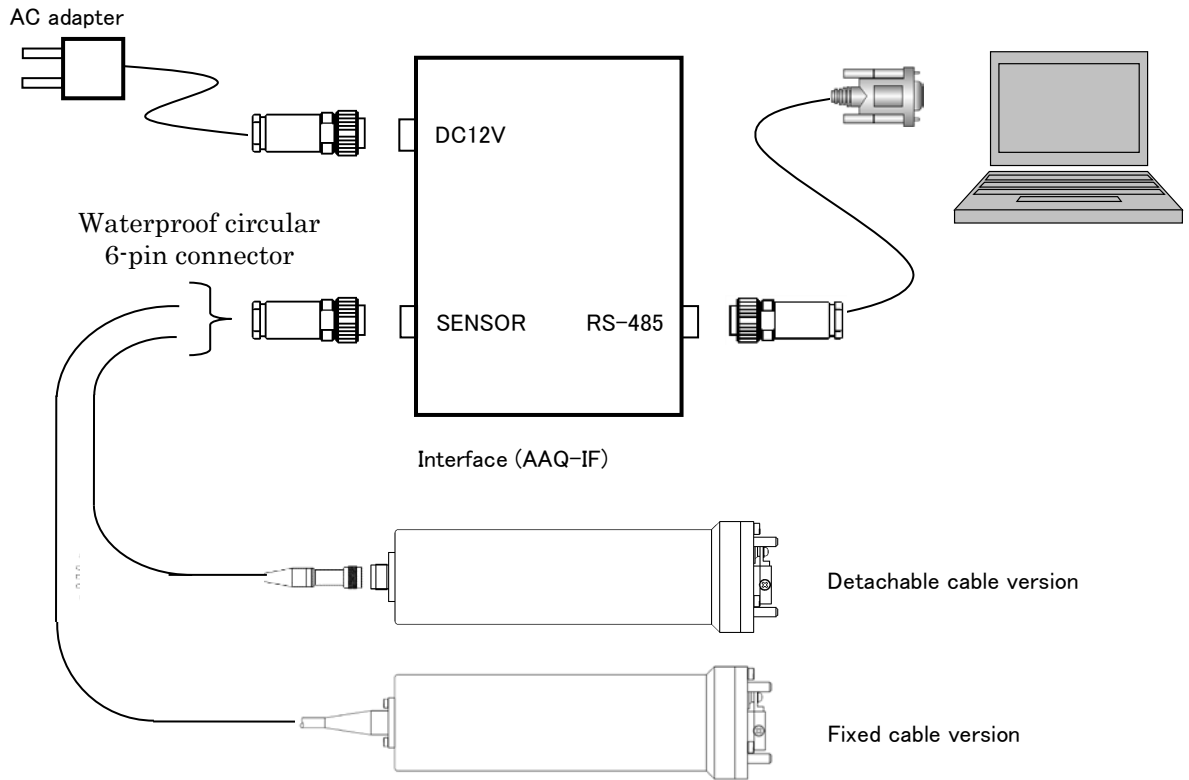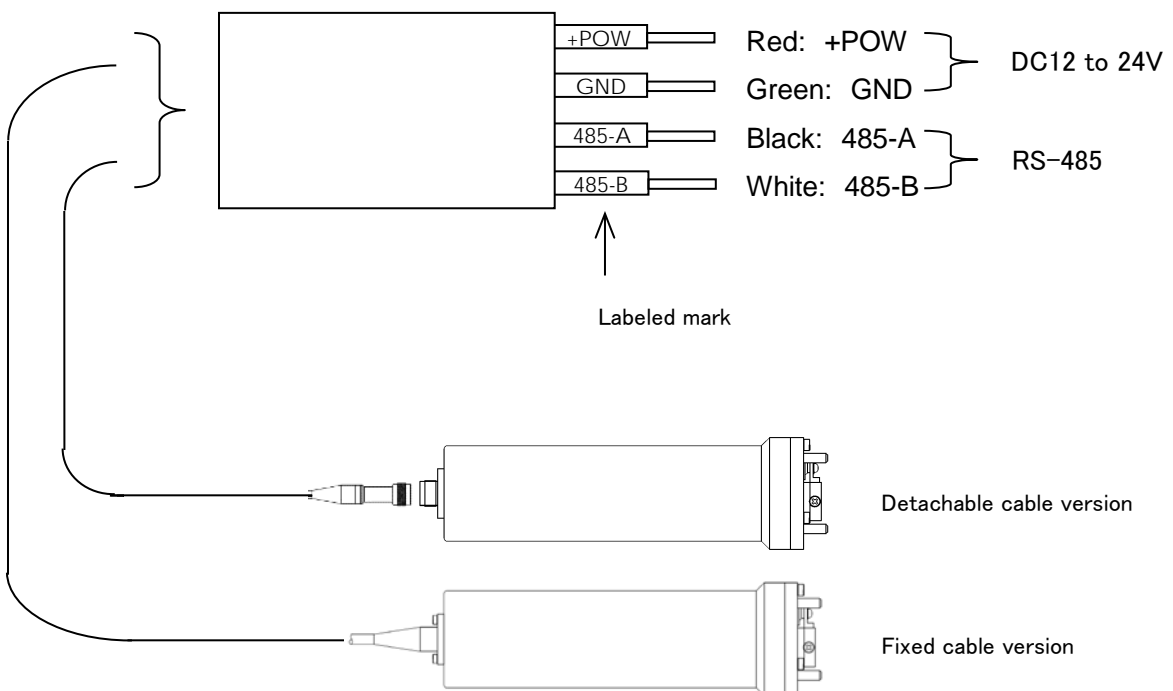
5.2　Attaching and detaching the waterproof connector
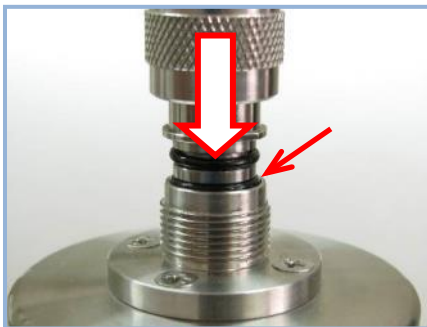
Apply grease

（1）Communication cable (in the connector end)

Check if there is no dust or anything else adhered to the o-rings.

Apply a small portion of silicon grease on the o-rings. If too much silicon grease is applied, there is a risk of dust or any other particle adhering to the o-rings more easily

Inner wall of the connector

（2）Inner wall of the connector in the instrument

Check if there is no dust or any kind of particles adhered to the wall.

（3）Connecting the cable to the instrument.

Adjust a position ensuring that male and female connectors fit correctly.

Insert the cable straightly to the instrument.

（4）Insert the cable connector firmly

Insert firmly until all O-rings are completely covered.

（5）Tighten the connector nut firmly until the end of the screw thread.

Note: After detaching the cable from the instrument, do not let the instrument and cable connectors without the protective cap. The protective cap helps to keep the instrument and cable connectors clean and free of particles until the next deployment.

6 Measurement

6.1 Measurement flowchart

The measurement flow is shown below. Connect the instrument to power supply and to PC (or control system) with RS-485 before measurement.

```
┌──────────────────────────────────────────────┐
│  Connect the instrument and PC(or control system)  │
└──────────────────────────────────────────────┘
                      │
          ┌───────────────────────────┐
          │  Set measurement configuration  │
          └───────────────────────────┘
                      │
              ┌──────────────────┐
              │  Start measurement  │
              └──────────────────┘
                      │
              ┌──────────────────┐
              │     Measuring      │
              └──────────────────┘
                      │
              ┌──────────────────┐
              │   Start logging    │
              └──────────────────┘
                      │
              ┌──────────────────┐
              │    Data logging    │
              └──────────────────┘
                      │
              ┌──────────────────┐
              │    Stop logging    │
              └──────────────────┘
                      │
              ┌──────────────────┐
              │   Stop measuring   │
              └──────────────────┘
```

Measuring only

Data logging

```
          ┌───────────────────────┐
          │    Data processing    │
          │   (by Excel or other)  │
          └───────────────────────┘
                      │
          ┌───────────────────────┐
          │   Calculation of      │
          │  FSI and Chlorophyll  │
          │   (by Excel or other)  │
          └───────────────────────┘
```
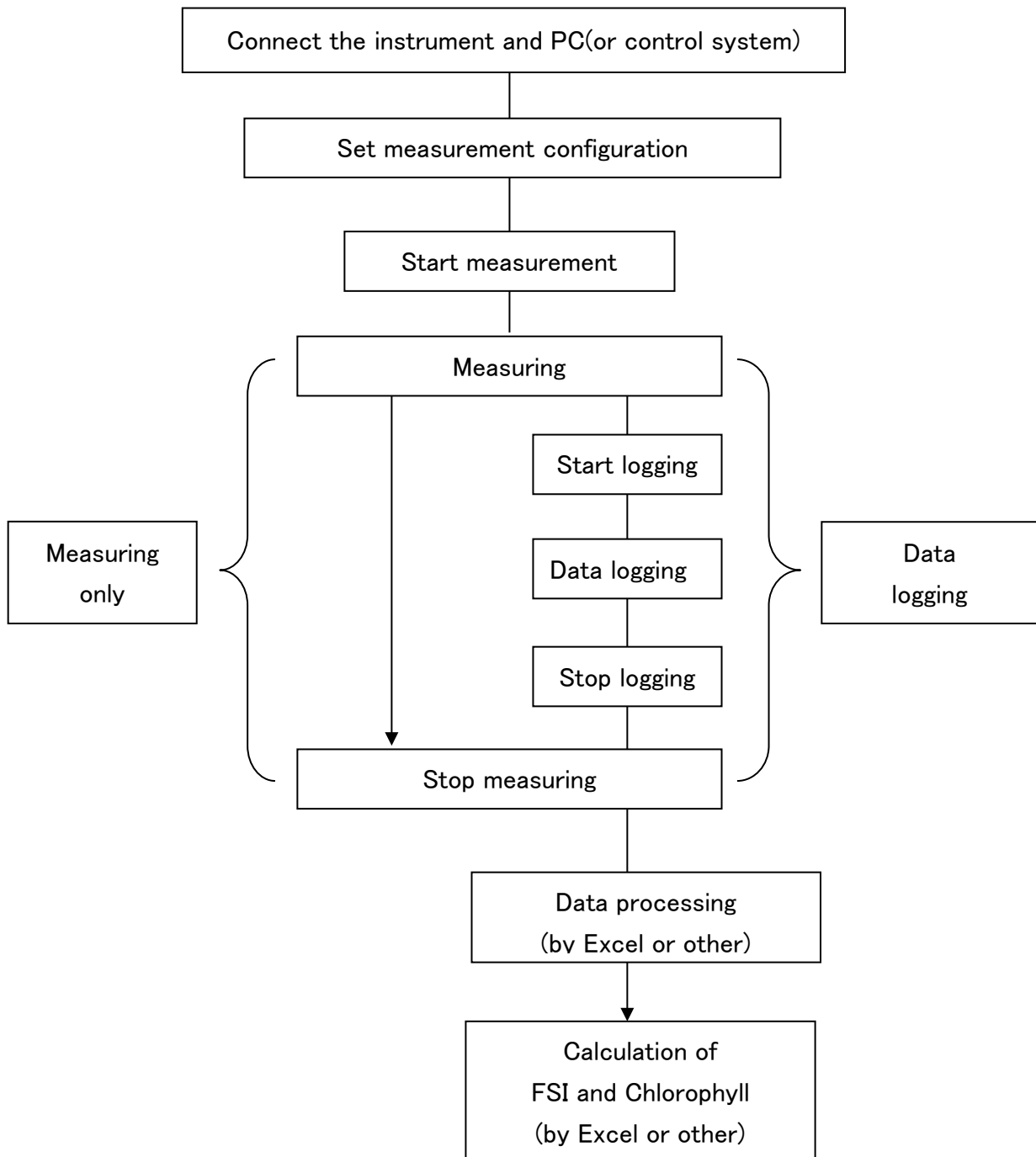
6.2 Measurement mode

Measurement can be controlled by sending the command.

Operate the wiper regular.

Recommended sampling interval time:

Power on | Data output via command

Preheat

Sampling interval time
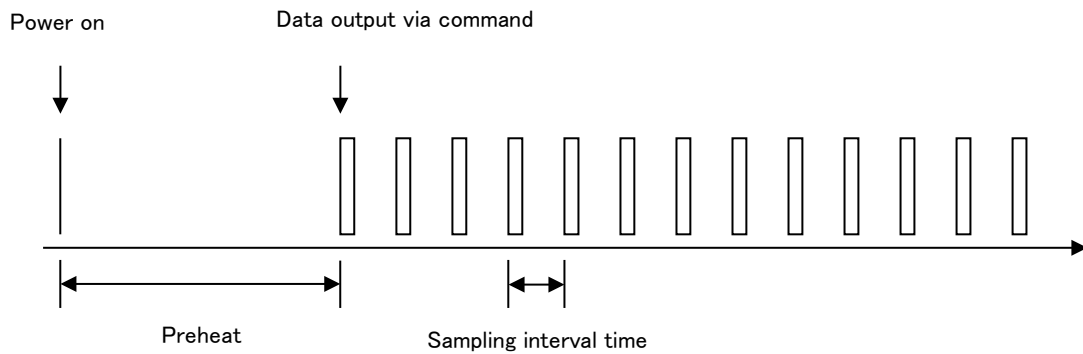
Note (1): No data can be obtained when the instrument is preheating(1.0s) or while the wiper is moving.

Example

Wiper motion

Start | Finish | Data output via command

Preheat

Sampling interval time

No data output
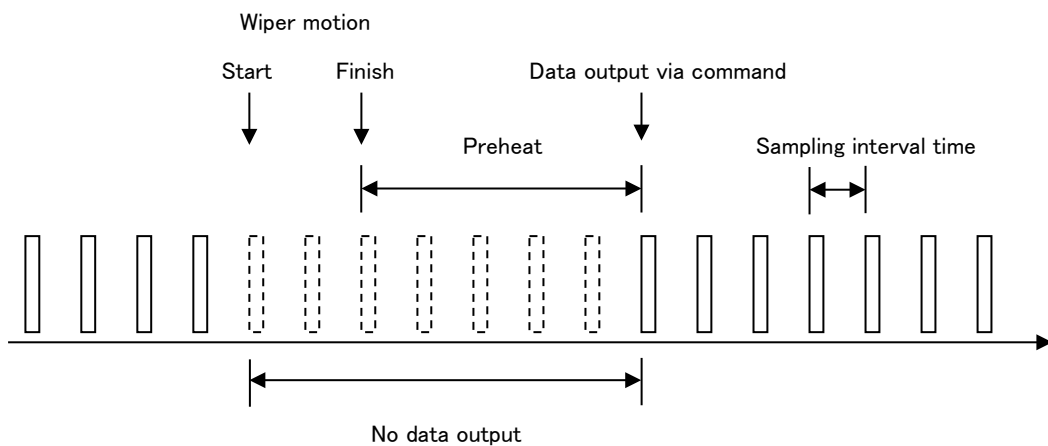
7 Communication

7.1 Communication specifications

Items	Specifications
Baud rate	Default: 38400 (configurable to 4800,9600,19200 or 38400 at the factory and before shipment)
ID	01(Default)
Character length	8 bit, fixed
Stop bit	1 bit, fixed
Parity	None, fixed
Bust control	None
Interface	RS-485
Terminating resistor	Default: Attached (Configurable to non-attached before the shipment)

> The instrument may not be operated normally when you send the command to the instrument before receiving the command
> The response time might need a few ms to 1 s based on commands.

Control codes

Notation	Code
<cr>	0Dh

- All characters are ASCII.
- PC means a personal computer or a control system.

7.2 **Command list**

All characters are ASCII

Main instruction	ID	,	Command	,	SUB command	,	End
? : read	Instrument ID						<cr>
= :response	(00 is the common ID)						

> ● If there is no response from the device, send the command several times.

    e.g) PC→Instrument   ?01,SERI,<cr>
        PC←Instrument   =01,SERI,0BWS007,<cr>

（1）Checking the serial number
        PC→Instrument   ?ID,SERI,<cr>
        PC←Instrument   =ID,SERI,<S-No>,<cr>

    e.g) PC→Instrument   ?01,SERI,<cr>
        PC←Instrument   =01,SERI,0BWS007,<cr>

（2）Checking the firmware version
        PC→Instrument   ?01,VERS,<cr>
        PC←Instrument   =ID,VERS,<F-ver>,<cr>

    e.g.)   PC→Instrument   ?01,VERS,<cr>
        PC←Instrument   =01,VERS,1.16,<cr>

    <F-ver>: shows the firmware version.

（3）Wiper operation
Do not send another command while wiper is working.

        PC→Instrument   ?01,WIPE,0,<cr>
        PC←Instrument   =01,WIPE,0,<cr>

（4） Checking the instrument ID

        PC→Instrument   ?ID,HEAR,87,<cr>

        PC←Instrument   =ID,HEAR,ID,<ID>,1,<cr>

    e.g.) PC→Instrument   ?01,HEAR,87,<cr>

        PC←Instrument   =01,HEAR,ID,01,1,<cr>

（5） Checking calibration coefficients

There are 11 channels with 8 calibration coefficients each (A, B, C, D, E, F, G, H)

        PC→Instrument   ?ID,COFE,<cr>

        PC←Instrument   =ID,COFE,Ch1A,Ch1B,Ch1C,Ch1D,Ch1E,Ch1F,Ch1G,Ch1H,

                  …,ChXH,<cr>

     Ch2: Temperature, Ch6:Chlorophyll, Ch7: adjustment coefficient, Ch9:F670,

     Ch10:F690, Ch11:power supply voltage

    e.g) PC→Instrument   ?01,COFE,<cr>

      PC←Instrument   =01,COFE,+1.234567e-02,-3.456789e+01,…,

                  0,0.00043,0,0,0,0,0,0,<cr>

（6） Physical data

The number of display digits of integer is variable. Refer to the number of decimal places
as follows

Temperature（Ch2）:	3 digits
Chlorophyll(Ch6):	8 digits
F670(Ch9) :	8 digits
F690(Ch10):	8 digits
Power supply voltage(Ch11):	2 digits

<stat> shows the instrument status (refer to status information)

PC→Instrument　?ID,PVAL,<cr>

PC←Instrument　=ID,PVAL,Ch.1 physical value,Ch.2 physical value,…,

Ch.11 physical value,<stat><cr>

Ch2: Temperature, Ch6:Chlorophyll, Ch9:F670, Ch10:F690,

Ch11:power supply voltage

Some figures might be inputted in unused channels.

e.g) PC→Instrument　?01,PVAL,<cr>

PC←Instrument　=01,PVAL, 30384.0,26.062,0.0,0.0,0.0,2.06064653,0.0,0.0,

0.33561604,0.10148004,11.75,0

（7） AD value data

AD value is the raw output data of the instrument (16bit AD conversion)

<stat> shows the instrument status (refer to status information)

PC→Instrument　?01,NVAL,<cr>

PC←Instrument　=ID,NVAL,Ch.1AD value,Ch.2 AD value,Ch.3

AD value,…,Ch.11 AD value,<stat>,<cr>

Ch2: Temperature, Ch6:Chlorophyll, Ch9:F670, Ch10:F690,

Ch11:power supply voltage

Some figures might be inputted in unused channels.

e.g) PC→Instrument　?01,NVAL,<cr>

PC←Instrument　=01,NVAL,30715,37273,␣␣␣␣0,␣␣␣␣␣0,␣␣␣␣␣0,␣␣

942,␣␣␣␣␣0,␣␣650,␣1085,␣␣819,27250,0,<cr>

※␣Indicates space

（8） Status Information

The notation is a decimal number, but the contents are meaningful in binary numbers.

Bit	Details
8-2bit	Internal Information (for maintenance)
8-1bit	Wiper operation（0:Not working, 1: working）

e.g) 00000001　→　Wiper is working

8 Calculation of physical value

(1) Temperature [°C] is calculated from the equation below:

$$\text{Temperature[°C]} = \sum_{i=0}^{n} Ci \cdot N_{temp}^{i}$$

N_{temp} : Temperature AD Value

C0~C7: Temperature coefficients Ch2A value to Ch2H value

(2) Chlorophyll [ppb] is calculated from the equation below:

$$\text{Chlorophyll[ppb]} = \sum_{i=0}^{n} Ci \cdot N_{chl}^{i}$$

N_{chl} : Chlorophyll AD value

C0~C7：Chlorophyll coefficients Ch6A value to Ch6H value

(3) 670nm fluorescence intensity(F670) [ppb] is calculated from the equation below.

$$\text{F670[ppb]} = \sum_{i=0}^{n} Ci \cdot N_{F670}^{i}$$

N_{F670} : F670 AD value

C0~C7：670nm fluorescence intensity coefficients Ch9A value to Ch9H value

(4) 690nm fluorescence intensity(F690) [ppb] is calculated from the equation below

$$\text{F690[ppb]} = \sum_{i=0}^{n} Ci \cdot N_{F690}^{i}$$

N_{F690} : F690 AD value

C0~C7：690nm fluorescence intensity coefficients Ch10A value to Ch10H value

(5) Power supply voltage [V] is calculated from the equation below.

$$\text{Power supply voltage [V]} = \sum_{i=0}^{n} Ci \cdot N_{batt}^{i}$$

N_{batt} : Power source AD value

C0~C7：Power supply voltage Ch11A value to Ch11H value

9 FSI

FSI（Fluorescence spectral Shift Index） is the reference value of expressing fluorescence spectrum shift and is the effective reference value of detecting harmful phytoplankton (e.g. Karenia mikimotoi)

However, under some conditions such as species dominating rate, fluorescence from other species may make HAI sensor unable to detect harmful phytoplankton.

It is highly recommended by using HAI sensor together with microscopic examination for final detection of harmful phytoplankton.

※**FSI=Fluorescence spectral Shift Index**

9.1 Calculation of FSI

FSI is calculated from the fluorescence intensity ration between wavelength of 670 nm and 690 nm. It may be expressed as .

$$\text{FSI} = \text{Ch7C} \times \frac{F690}{F670} + \text{Ch7}D$$

F670：Output value of 670nm fluorescence intensity
F690：Output value of 690nm fluorescence intensity
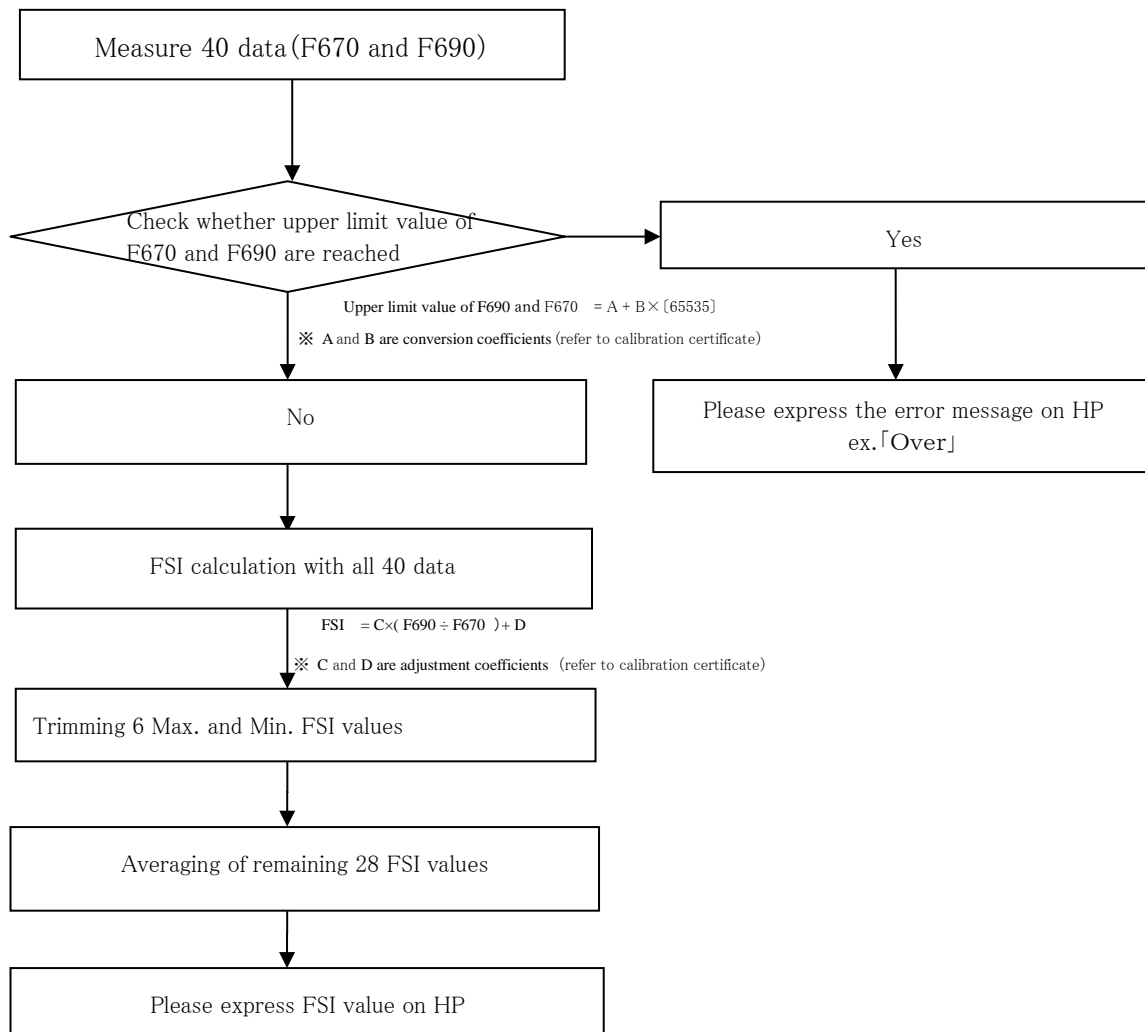Ch7C and Ch7D are coefficients ([3]).

Regarding to Ch7C and Ch7D, they are given in the calibration certificate or they are stored in channel 7 inside the instrument.

※([3]) Ch7C and Ch7D are different from each instrument. They will change If the recalibration is conducted.

Note:

If F690 or F670 becomes 0 or minus value, please consider FSI=0.

9.2 **FSI data processing flow**

```
┌─────────────────────────────────────────┐
│      Measure 40 data (F670 and F690)     │
└─────────────────────────────────────────┘
                    │
                    ▼
          ◇────────────────────◇
          │ Check whether upper │           ┌──────────────────────┐
          │ limit value of      │──────────▶│         Yes          │
          │ F670 and F690 are   │           └──────────────────────┘
          │ reached             │                      │
          ◇────────────────────◇                      │
```

Upper limit value of F690 and F670 $= A + B \times$〔65535〕

※ A and B are conversion coefficients (refer to calibration certificate)

```
┌─────────────────────────────┐        ┌──────────────────────────────┐
│             No              │        │ Please express the error     │
└─────────────────────────────┘        │ message on HP                │
                │                       │ ex.「Over」                    │
                ▼                       └──────────────────────────────┘
┌─────────────────────────────┐
│  FSI calculation with all 40 data │
└─────────────────────────────┘
```

FSI $= C \times ($ F690 $\div$ F670 $) + D$

※ C and D are adjustment coefficients (refer to calibration certificate)

```
┌─────────────────────────────────────────┐
│     Trimming 6 Max. and Min. FSI values  │
└─────────────────────────────────────────┘
                    │
                    ▼
┌─────────────────────────────────────────┐
│     Averaging of remaining 28 FSI values │
└─────────────────────────────────────────┘
                    │
                    ▼
┌─────────────────────────────────────────┐
│        Please express FSI value on HP    │
└─────────────────────────────────────────┘
```

9.3 **FSI data processing**

Due to spatial changes of in-situ phytoplankton florescence , the measured FSI might include extreme large or small values. Therefore, at least 40 data should be measured and the averaging should be done after trimming approx.15% of data (large and small).

If Phytoplankton fluorescence value is too high and F690 or F670 reaches the upper limit value, we recommend setting the error message when F690 or F670 reaches the limit value.

Upper limit value means its AD value is 65535.

If you output data in the physical value, the upper limit value should be calculated in advance by AD value and calibration coefficients of F670 and F690 as following

(1) F670 upper limit value

$$F670 = Ch9A + Ch9B \times [65535]$$

Ch9A: Calibration coefficient A of 670nm fluorescence intensity,

Ch9B: Calibration coefficient B of 670nm fluorescence intensity

Refer to the calibration certificate or they are recorded in channel 9 of the instrument.[4]

(2) F690 upper limit value

$$F690 = Ch10A + Ch10B \times [65535]$$

Ch10A: Calibration coefficient A of 690nm fluorescence intensity,

Ch9B: Calibration coefficient B of 690nm fluorescence intensity

Refer to the calibration certificate or they are recorded in channel 10 of the instrument.[4]

※[4] calibration coefficients are different from each instruments.
     If the recalibration is done, they are modified.

9.4 **FSI threshold**

If you set threshold of FSI, please set the range of 1.90 to 2.00(recommended value：1.90).

The recommended vale is just only general recommendation. It becomes different from sea areas or environment. Please adjust it by yourself based on measured data by microscopic examination.

10 Chlorophyll data

AHIW2A-CAD has a different LED from INFINITY-CLW and Multi-Exciter in order to measure fluorescence intensity at 670nm and 690nm effectively.

If you compare chlorophyll fluorescence data between INFINTY-CLW(or Multi Exciter) and AHIW2A-CAD, please multiply the chlorophyll fluorescence data of AHIW2A-CAD by 1/3.

However, the chlorophyll fluorescence data here is just only reference and we cannot guarantee the accuracy.

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11 Maintenance

11.1 Maintenance after use

1. Please wash the instrument with fresh water and gently wipe it with soft cloth in water.
2. Be careful when removing fouling on the sensor surface.
   If the sensor surface is washed by a hard brush, it might damage the sensor and influence the measured data.
3. Do not wash the optical sensor by thinner, ethanol and acetone.

11.2 Storage

1. Do not store the instrument in direct sunlight, in places with temperature exceeding 45℃ and in high humid or dusty places.
2. Do not use the instrument in freezing places although the temperature range is -3 to 45℃.

⚠ Caution
● **Do not drop the instrument or add it to the impact.**

11.3 Disposal

When disposing of this product, do so in the appropriate manner following all laws and regulations.

11.4 Sensor inspection and recalibration

Sensor inspection and recalibration should be done in our factory to keep the accuracy once a year (incl. internal check, replacement of wiper rubber and recalibration).

12 Sensor principal

・Chlorophyll sensor

　　The Chlorophyll sensor measures the intensity of Chlorophyll fluorescence, which must be emitted as energy wasted during photosynthesis by phytoplankton. This fluorescence intensity almost depends on the concentration of Chlorophyll a, a photosynthetic pigment essential for phytoplankton. Therefore, by measuring this intensity, it is possible to know the increase or decrease in Chlorophyll concentration, which is an indicator of the abundance of phytoplankton.

・FSI sensor

　　The FSI (fluorescence spectral shift index) sensor can detect harmful species (Karenia mikimotoi and Chattonella antiqua) which could not be detected with the conventional chlorophyll sensor.

The fluorescence spectra of Karenia mikimotoi and Chattonella antica are slightly different from those of other species. The fluorescence intensity near 670 nm and 690 nm in the fluorescence spectrum is spectroscopically measured with an optical filter, and the ratio is calculated to derive the FSI. FSI expresses the difference in the fluorescence spectrum and is used to detect two types of harmful plankton.
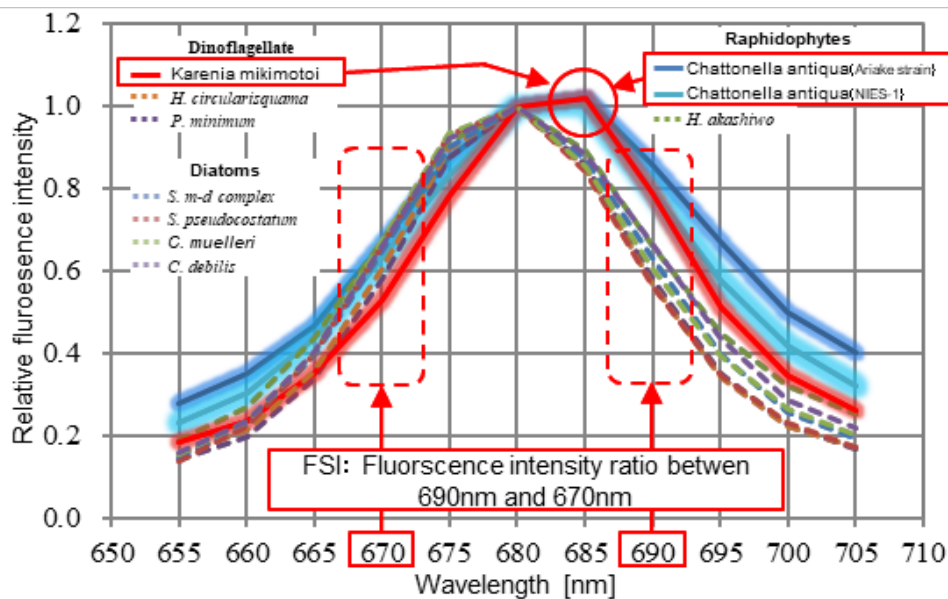
Detection wavelength of phytoplankton

13 Troubleshooting

No	Problem	Action
1	Cannot communicate with PC (or control system).	Check the power supply and the connecting port number.
2	Measurements do not start.	Check the power supply voltage and connection.
3	Lack of data.	Data cannot be obtained during wiper movement or while the instrument is preheating. Check if the wiper working or if the instrument is preheating.
4	The wiper does not operate smoothly.	Disassemble and clean the wiper Contact us.(1)
5	The temperature sensor is bent.	It is possible that the sensor is not outputting the correct water temperature. We recommend an inspection at our factory.(1)

14 Specifications

14.1 Instrument specifications

Item	Specifications
Power supply voltage	DC12V to 24V
Power consumption	120mA below（ at DC12.0V）
Preheat time	1.0 s
Communication	RS-485
AD conversion	16 bit
Baud rate	Default: 38400 (configurable to 4800,9600,19200 or 38400 at the factory and before shipment)
ID	01(Default)
Character length	8 bit（fixed）
Stop bit	1 bit（fixed）
Parity	None（fixed）
Busy control	None
Terminating resistor	Default: Attached (Configurable to non-attached before the shipment)
Depth rating	50 m depth equivalent
Material	Titanium(grade 2)
Weight	Approx. 0.9kg in air，approx. 0.4kg in water
Cable length	20m(standard) Max.50m
Cable type	Detachable cable or fixed cable
Cable termination	1. Unbraided 2. Waterproof circular 6-pin connector.
Dimension	Approx. φ70mm×176mm(Not incl. cable)

14.2 Sensor specification

Parameter	Temperature	Chlorophyll	FSI
Principle	Thermistor	Fluorescence	Ratio of fluorescence intensity
Range	-3〜45 ℃	0 to 400ppb (Uranine reference)	-
Accuracy	±0.02 ℃ （3 to 31℃）	Non-linearity ±1%FS (0 to 200ppb)	Repeatability ±0.05 (0 to 200ppb)

15 Warranty

(1) The warranty period is <u>one year</u> from the date of ship-out date.
   During this period, if a problem is considered to be a design or manufacturing defect, or malfunction upon a normal condition, JFE Advantech will take it as warranty.

(2) Scratch, stain, rust, and others on accessories, expendables, packages, and exteriors are out of warranty.

(3) Note that fees are applied in the cases listed below even within the warranty period.
   ① Damage caused during installation, mooring, or storage.
   ② Malfunction and/or damage caused by wrong operation or carelessness.
   ③ Malfunction and/or damage caused by improper repair and modification.
   ④ Malfunction and/or damage caused during transportation, by fall, and/or impact after purchase.
   ⑤ Malfunction and/or damage due to external causes such as fire, earthquake, flood, lightening, other natural disasters, public nuisance, and/or abnormal voltage.
   ⑥ Malfunction and/or damage caused by abnormality of device(s) connected to a customer's system.
   ⑦ Replacing the expendables
   ⑧ Malfunction and/or damage caused by changing expendable parts, such as O-ring and wiper-blade, by user him/herself or by a third person(s).
   ⑨ Malfunction caused by a non JFE Advantech product(s), such as your instrument, software, and etc.

(4) Note that JFE Advantech will not be liable for any damage and/or profit loss caused by the use of the instrument and/or any claim by a third party.

(5) <u>Damage during installation or shipment is out of warranty.</u> Consider obtaining insurance if such damage is concern.

(6) Additional six months limited warranty will be given for any repairs done at JFE Advantech. This limited warranty will be applied only to the repaired item with same malfunction/symptom. However, fee will be charged with listed cases under (3) even in the period.

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