



Clamp-on Flow Sensor

FD-X Series



Instruction Manual

Read this manual before using the product in order to achieve maximum performance.
Keep this manual in a safe place after reading it so that it can be referenced at any time.

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■ Symbols

This instruction manual uses the following symbols to alert readers to important messages.
Be sure to read these messages carefully.

	It indicates a hazardous situation which, if not avoided, will result in death or serious injury.
	It indicates a hazardous situation which, if not avoided, could result in death or serious injury.
	It indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
	It indicates a situation which, if not avoided, could result in product damage as well as property damage.

	It indicates cautions and limitations that must be followed during operation.
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	It indicates additional information on proper operation.
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	It indicates tips for better understanding or useful information.
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Indicates items and pages in this manual being referenced.

1 Before Operation

1-1 Safety Precautions

■ General cautions

	- Do not use the FD-X Series out of the specification ranges. Comply with the contents described in this instruction manual when using the product. - Do not use the FD-X Series for facilities where death or serious property damage is possible, such as nuclear power generation, aircraft, railway, ship, vehicles, medical equipment, playground equipment, etc. - Do not use this product for the purpose of protecting a human body or a part of a human body. - This product is not intended for use as an explosion-proof product. Do not use this product in a hazardous location and/or potentially explosive atmosphere.
	- Do not modify the FD-X Series. - If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

■ Precautions for handling

	When installing the FD-X Series on a high-temperature pipe, the sensor head can become hot. Be careful not to burn yourself.
	- Do not drop the FD-X Series, hit it against something, or apply excessive force. - Do not use a sharply pointed object to press the setting keys.

■ Precautions for detectable fluid

	- High-viscosity, high-turbidity, or sparkling fluid may cause unstable detection. Keep this in mind before using. - When the fluid temperature rises or pressure is reduced, bubbles may form in the fluid within the pipe, resulting in unstable detection.
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■ Precautions for wiring

	Use the FD-X Series within the rated range. The FD-X is a product that uses a DC (direct current) power source. Do not apply AC (alternating current) or other power supplies. Do not use a load that exceeds the allowable limit.
	- Before wiring the FD-X Series, confirm the colors of the wires. - Use an insulated stabilizing power supply. - Do not apply excessive tensile force to the cable. - Ensure that the cable tip is not submerged in water during wiring work. - Isolate the cable from power supply lines or power lines when wiring. - Isolate the cable as far away as possible from in-cable source of noise. - The total length of the cable from the in-cable amplifier to the controller must be shorter than 12 m. The total length of the power cable of the controller must be shorter than 30 m.

■ Precautions for installation

	Do not install the FD-X Series in locations used as footholds.
	- Install the FD-X Series in a location where the inside of the measuring pipe is always filled with fluid. - To prevent a situation where the FD-X Series is affected by the pipe not being filled with fluid, it is recommended to secure it in a position where the display surface is perpendicular to the ground. - When the fluid contains bubbles, detection performance of the FD-X may be affected. - When installing the FD-X Series on a vertical pipe, choose a position where the fluid flows in the upward direction. - In order to improve the detection stability, it is recommended to secure a straight pipe section that is 20 times larger than the pipe inner diameter (100 times or more for reduced pipe) on the upstream side of the sensor. - Install the sensor on the upstream side of a flow regulating valve or similar piece of equipment. - Install the FD-X Series on a surface with no seams or rust. - Do not install the FD-X Series in a location exposed to intense light, such as direct sunlight, or radiation from a heat source. - When installing the FD-X Series in a location where vibrations occur, secure the pipe with tubes or supports as close to the main unit as possible. Excess vibration may cause unstable behavior or apply stress on the pipe. - When connecting the FD-X Series to a metal pipe with an outer diameter of $\phi 8.3\text{mm}$ or smaller, and high vibration or impact is possible, we recommend securing the sensor head using the optional bracket (OP-88297) to mitigate the stress on the pipe. - To avoid interference between detection signals, do not install multiple units closely in series. - Since the heat of the in-cable amplifier may affect the liquid temperature, it is recommended to fix the amplifier to a location other than the pipe. - In order to improve the detection stability, please do not apply load to the cable between the sensor head and in-cable amplifier as much as possible.

■ Other precautions

	- When power is applied to the sensor, it enters an 8 second "start-up" process before it is ready to use. Do not use the outputs from the sensor during this period. - Initial drift may occur after the power is turned on. To detect a subtle difference in the flow rate, let the FD-X Series warm up for approx. 15 to 30 minutes before use. - Do not bring a strong magnet or magnetic field close to the main body of the FD-X Series.
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	Do not use the FD-X Series as a measurement instrument for trade or certification.
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1-2 Notes on regulation and standard

■ CE marking

Keyence Corporation has confirmed that this product complies with the essential requirements of the applicable EU Directive(s), based on the following specifications. Be sure to consider the following specifications when using this product in the Member States of European Union.

● EMC Directive

- Applicable standard EN61326-1, Class A

Remarks: These specifications do not give any guarantee that the end-product with this product incorporated complies with the essential requirements of EMC Directive. The manufacturer of the end-product is solely responsible for the compliance on the end-product itself according to EMC Directive.

■ CSA Certificate

This product complies with the following CSA and UL standards and has been certified by CSA.

- Applicable Standard CAN/CSA C22.2 No.61010-1
UL61010-1

Be sure to consider the following specifications when using this product as a product certified by CSA.

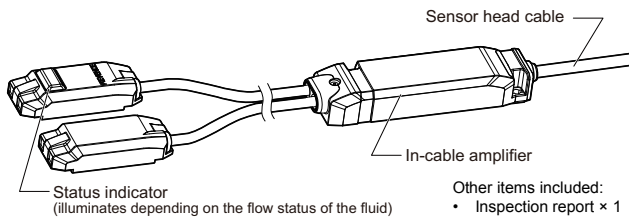
- Over voltage category I
- Pollution degree 3
- Indoor use
- Use this product at the altitude of 2000 m or less
- Use the CSA/UL Listed power supply which has the Class 2 output defined in CEC (Canadian Electrical Code) and NEC (National Electrical Code).

2 Installation and Wiring

2-1 Checking the package

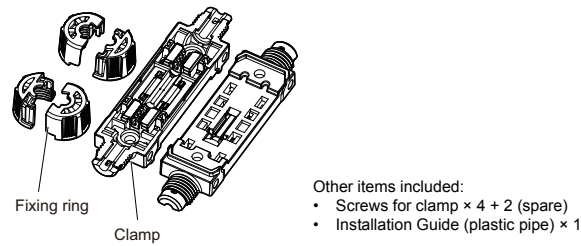
■ Sensor head (detector)

FD-XS1/XS8/XS20



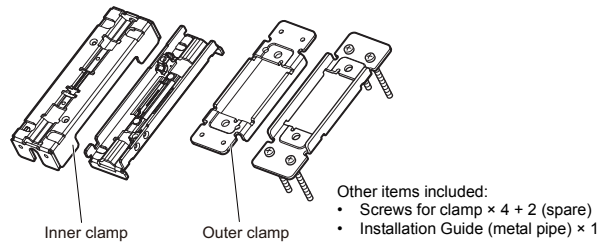
■ Clamp set for plastic pipes

For FD-XS1 FD-XC1R1/XC1R2
For FD-XS8 FD-XC8R1/XC8R2/XC8R3
For FD-XS20 FD-XC20R1/XC20R2/XC20R3/XC20R4



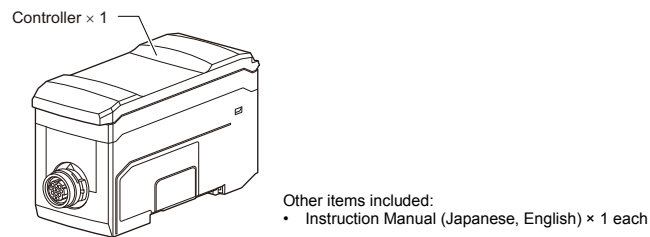
■ Clamp set for metal pipes

For FD-XS1 FD-XC1M
For FD-XS8 FD-XC8M
For FD-XS20 FD-XC20M1/XC20M2



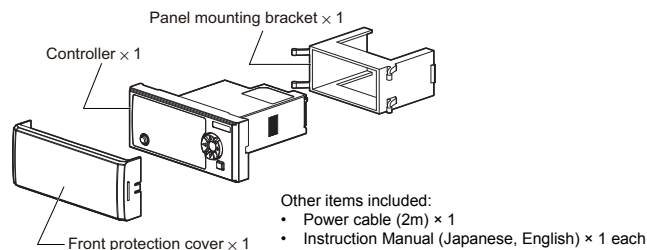
■ Controller (DIN rail mounting)

FD-XA1/XA2



■ Controller (panel mounting)

FD-XA5

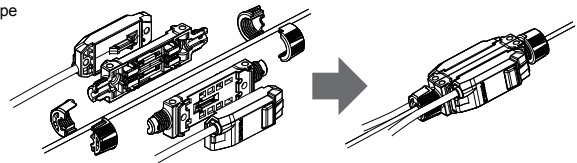


2-2 Installing the Sensor Head on a Pipe

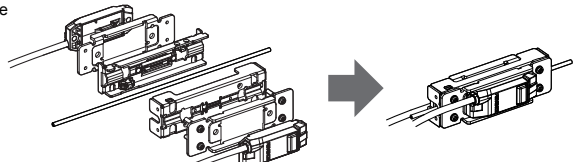
The sensor head is installed on a pipe using the clamp set.

For detailed installation procedure, refer to the "Installation Guide" provided with each clamp set.

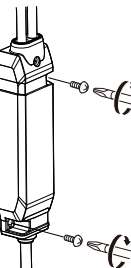
Plastic pipe



Metal pipe

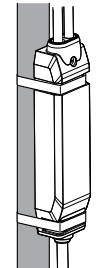


In-cable amplifier
(Mounting optional)



Fix with screws

or



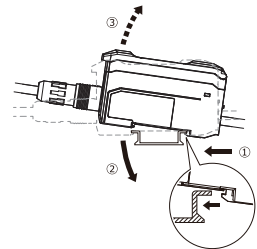
Fix with cable tie

2-3 Installing the Controller

■ DIN rail mounting

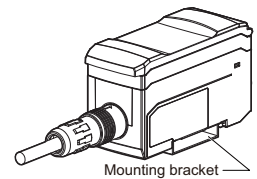
● Attaching the FD-XA1 (main unit)

- 1 Align the claw on the bottom of the main body with the DIN rail, as shown in the figure on the right. While pushing the main body in the direction of arrow (1), push down in the direction of arrow (2).



- 2 To remove the sensor, push the main body in the direction of arrow (1), while lifting the unit in the direction of arrow (3).

When using the mounting bracket (OP-88311 sold separately), mount the controller as shown on the right.



● Attaching the FD-XA2 (expansion unit)

Several expansion units can be used in conjunction with a main unit. Up to seven expansion units can be connected to one main unit.

CAUTION	Mount the product on a DIN rail and install on a metal surface when connecting multiple expansion units or mounting main units close together.
NOTICE	Turn the power off before connecting expansion units.

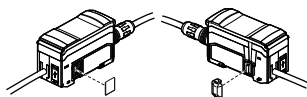
Point

- The maximum number of expansion units that can be connected is as follows.

Main unit	Expansion unit	Max. number of expansion units
FD-XA1	FD-XA2	7
FS-MC8N/MC8P	FD-XA2	4
NU series	FD-XA2	6
MU-N11	FD-XA2	4
FD-XA1	MU-N12	4
N-bus compatible sensor amplifiers other than the above (when the power cable is 2 m or less)	FD-XA2	7

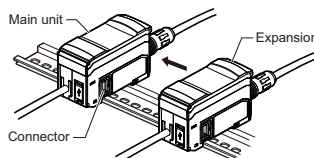
- Do not touch the expansion unit connectors.
- When using the FD-X Series with other series, use the lowest power supply voltage range capable for the connected units.

- 1 Remove the protection covers from the main unit and expansion unit(s).



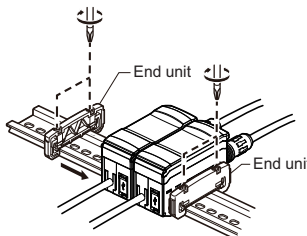
- 2 Install the expansion units on the DIN rail, one at a time.

The installation method is the same as that of the main unit.



- 3 Push the expansion unit into the main unit connector port until a clicking sound is heard.

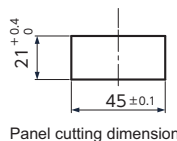
- 4 Using the same method as step (2), install the end units (OP-26751: 2 units in a set, sold separately) on the outer sides of the main unit(s) and expansion unit. Then, secure the end units in place.



■ Panel mounting

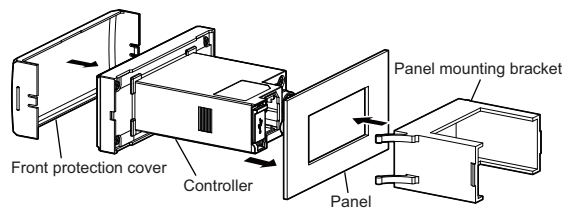
● Attaching the FD-XA5

- 1 Drill a cavity for mounting on the panel with the dimensions shown to the right.

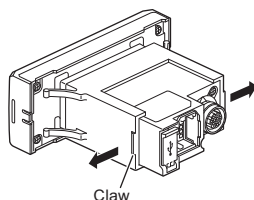


- 2 Insert the controller into the cavity on the panel from the front.

- 3 Orient the panel mounting bracket as shown below, attach it to the controller from the back, and attach the front protection cover to the controller.

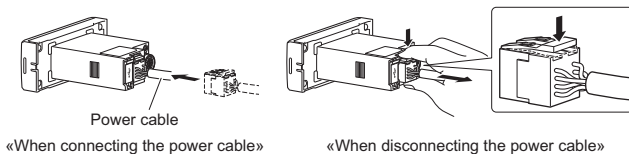


When removing the panel mounting bracket, widen the claws on both sides of the panel mounting bracket.



● Connecting the Power Cable to the FD-XA5

For the panel mount controller, you need to connect the included power cable.



2-4 Connecting the sensor head and the controller

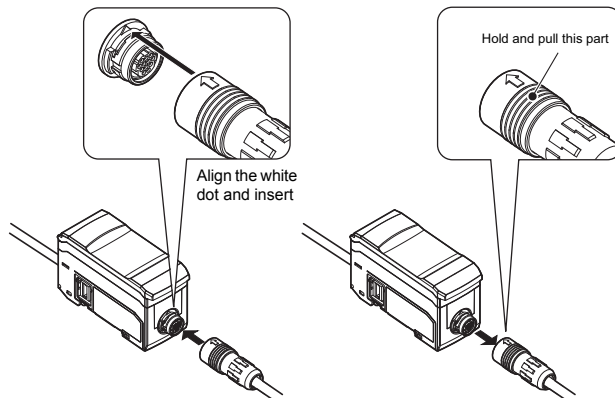
NOTICE

- Be sure to turn off the power before connecting the sensor head cable.
- Fully insert the sensor head cable. It may be disconnected if it is not inserted completely.

■ Connecting the sensor head to the controller

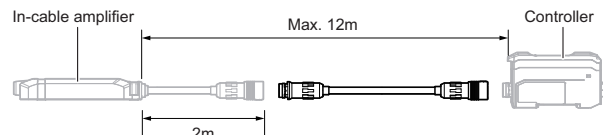
Connecting the cable

Disconnecting the cable



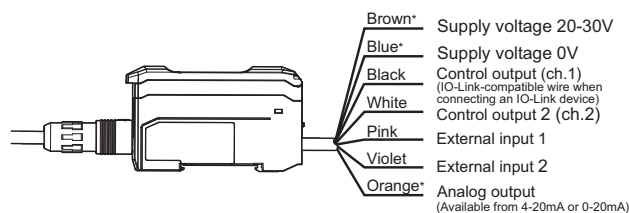
NOTICE

For extending the sensor head cable, use OP-88292 (extension cable 2m) or OP-88293 (extension cable 5m). The total length of the cable from the in-cable amplifier to the controller must be shorter than 12m.



2-5 Wiring

■ Wire color/function



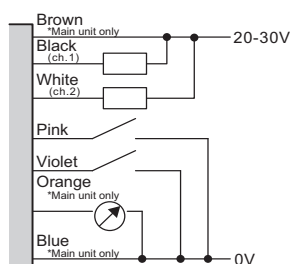
*There is no brown, blue, or orange wires with the FD-XA2 (expansion unit).

■ Wiring diagram

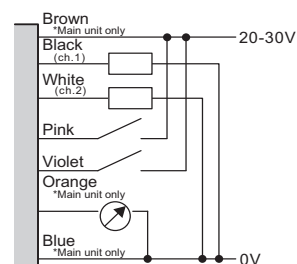
Insulate the input/output wires that are not used independently.

□ Load (input device) ⤵ Analog current input device

● NPN



● PNP



3 Initial Settings

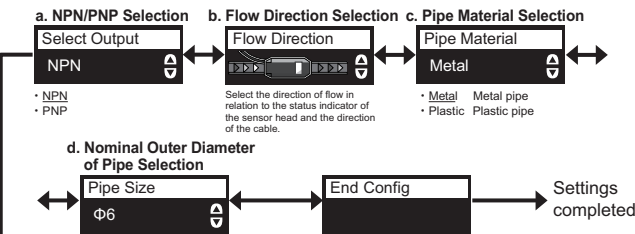
3-1 Settings when the power is turned on for the first time or after initialization

- This section describes settings that must be configured prior to using the device. The following screens are displayed "When the power is supplied to the unit for the first time" or "After the unit is initialized". During the initial settings, the 7-segment display is shows [init].
- Underlined items are default values.

Press or to move to the next menu screen.

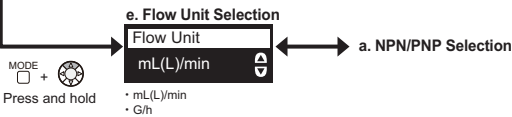
Press to return to the previous menu screen.

Press or to select a parameter.



FD-XS1	FD-XS8	FD-XS20
φ3	φ6	φ10
φ4	φ8	φ12
1/8"(3.18mm)	1/4"(6.35mm)	3/8"(9.53mm)
		1/2"(12.7mm)
		6A(10.5mm)
		8A(13.8mm)

Point When using the device in a low flow rate area, perform origin adjustment after the initial settings are completed. "Origin Adjustment" (page 14).



4 Display Settings

4-1 Main Display Screens

Operations available on Screen I

Configuring thresholds*¹
 or

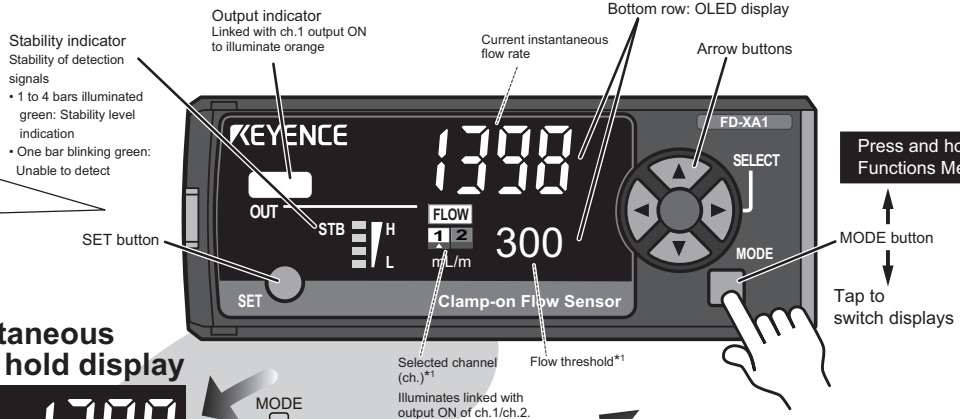
Switching thresholds L/H and ch.1/ch.2*²
 or

Full auto calibration (p.6)
 Press and hold

Origin adjustment (p.14)
 + Press and hold

Condition monitoring function (p.14)
 + Press and hold

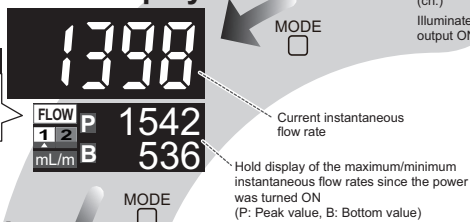
I Instantaneous flow rate display



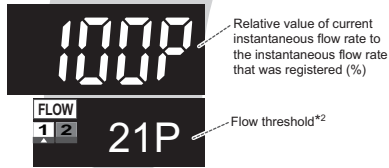
II Instantaneous flow rate hold display

Operation available on Screen II

Reset hold values
 + Press and hold



III Condition monitoring display (skipped when the condition monitoring function is not set)



Operation available on Screen III

Condition monitoring function (p.14)
 + Press and hold

IV Shot display (skipped when the shot mode is not set)



Operation available on Screen IV

Configuring thresholds*³
 or

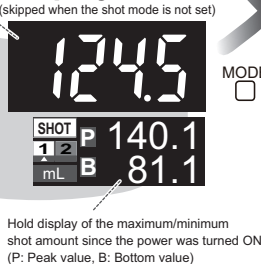
Switching thresholds L/H and ch.1/ch.2*³
 or

Full auto calibration (p.6)
 Press and hold

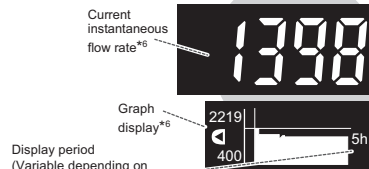
Multi shot calibration (p.14)
 Press shortly + Press and hold

Target calibration (p.14)
 + Press and hold

V Shot hold display (skipped when the shot mode is not set)



VII Graph display



Operation available on Screen VII

Changing the upper/lower limit range on the graph
 Changing with or

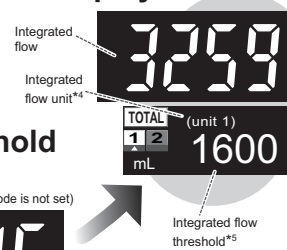
MODE Tap to switch the upper/lower limit on the display

Leave the display unattended for 3 seconds to complete the change

Checking the past data*⁷
 * Moving the cursor to the rightmost position or leaving the screen unattended for one minute brings back the current data.

Reset hold values (for a bar graph only)
 + Press and hold

VI Integrated flow display



Operation available on Screen VI

Configuring thresholds*⁵
 or

Resetting the integrated flow value
 + Press and hold

Operation available on Screen V

Reset hold values
 + Press and hold

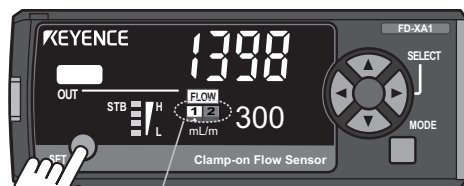
- *¹ In area mode, two settings, H (upper limit) and L (lower limit), are displayed for one channel (ch.), and each can be selected and configured. When the instantaneous flow rate mode or the area mode are not set, "-" is shown.
- *² This is linked to the instantaneous flow rate setting of ch.1. The settings cannot be changed on this screen.
- *³ Settings for channels in shot mode can be configured. In shot mode, settings for both ch.1 and ch.2 can be selected and configured.
- *⁴ The integrated flow unit is the amount of flow by which the integrated flow rate is counted up. It is configurable, see "11. Integrated flow unit" (page 7)
- *⁵ When ch.1 is in integrated flow mode, the setting is shown and is configurable. Otherwise, "-" is shown.
- *⁶ When set to the shot mode, the upper row shows the shot amount and the lower row shows a bar chart containing the hold values linked to the peak and bottom values of the shots since power-on.
- *⁷ The data stored and shown is: for the instantaneous flow rate chart, the last "recording cycle (mins.) x 200" (last 1000 mins. in default setting). The recording cycle can be changed in settings "F5. Recording Frequency" (page 15); for the shot rate chart, the data for the last 200 shots after power-on.

4-2 Automatic Configuration (Full Auto Calibration)

You can automatically configure the instantaneous flow rate or shot amount thresholds by just pressing-and-holding the SET button.

■ Setting the instantaneous flow rate threshold(s) (Instantaneous flow rate mode/Area mode)

Normal screen (I Instantaneous flow rate display)



If there are both ch.1 and ch.2, select the screen for the desired ch.

SET
○ Press and hold

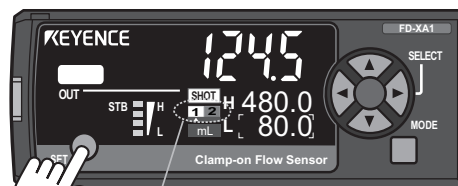
Release button



During instantaneous flow rate mode the threshold is set at 50% (fixed) lower than the current value, during area mode upper/lower limits are automatically set to $\pm 25\%$ (variable).

■ Setting shot amount thresholds (Shot mode)

Normal screen (IV Shot display)



If there are both ch.1 and ch.2, select the screen for the desired ch.

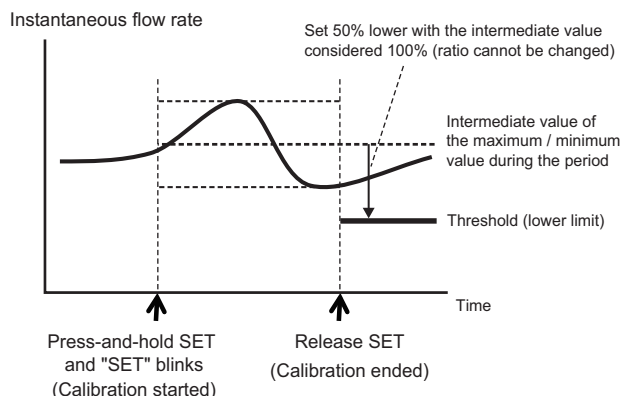
SET
○ Press and hold

Release button

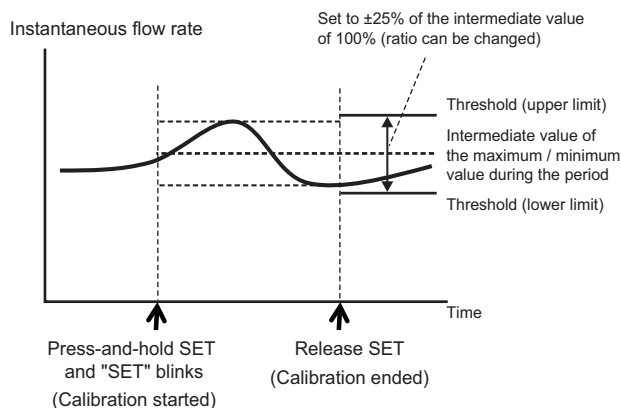


Upper/lower limits are automatically set to $\pm 25\%$ (variable) of the read value.

Instantaneous flow rate mode

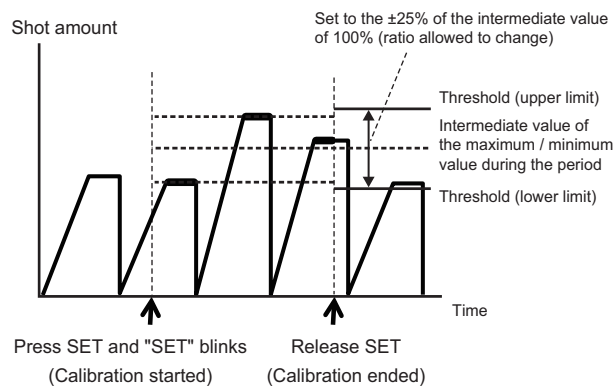


Area mode



The ratio of $\pm 25\%$ can be changed in "B1. Calibration target value (page 9)."

Shot mode

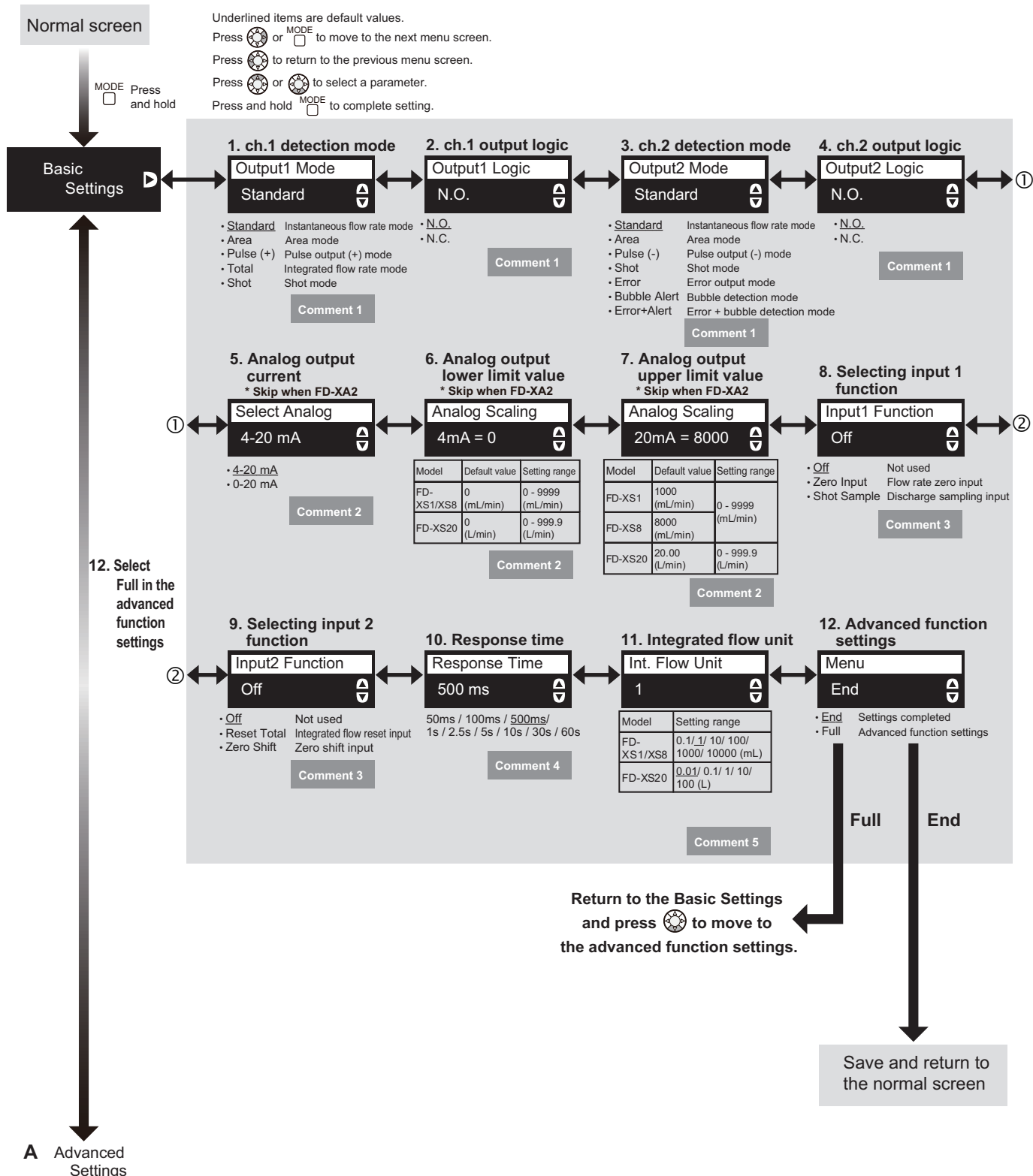


The ratio of $\pm 25\%$ can be changed in "B1. Calibration target value (page 9)."

5 Configuring Functions

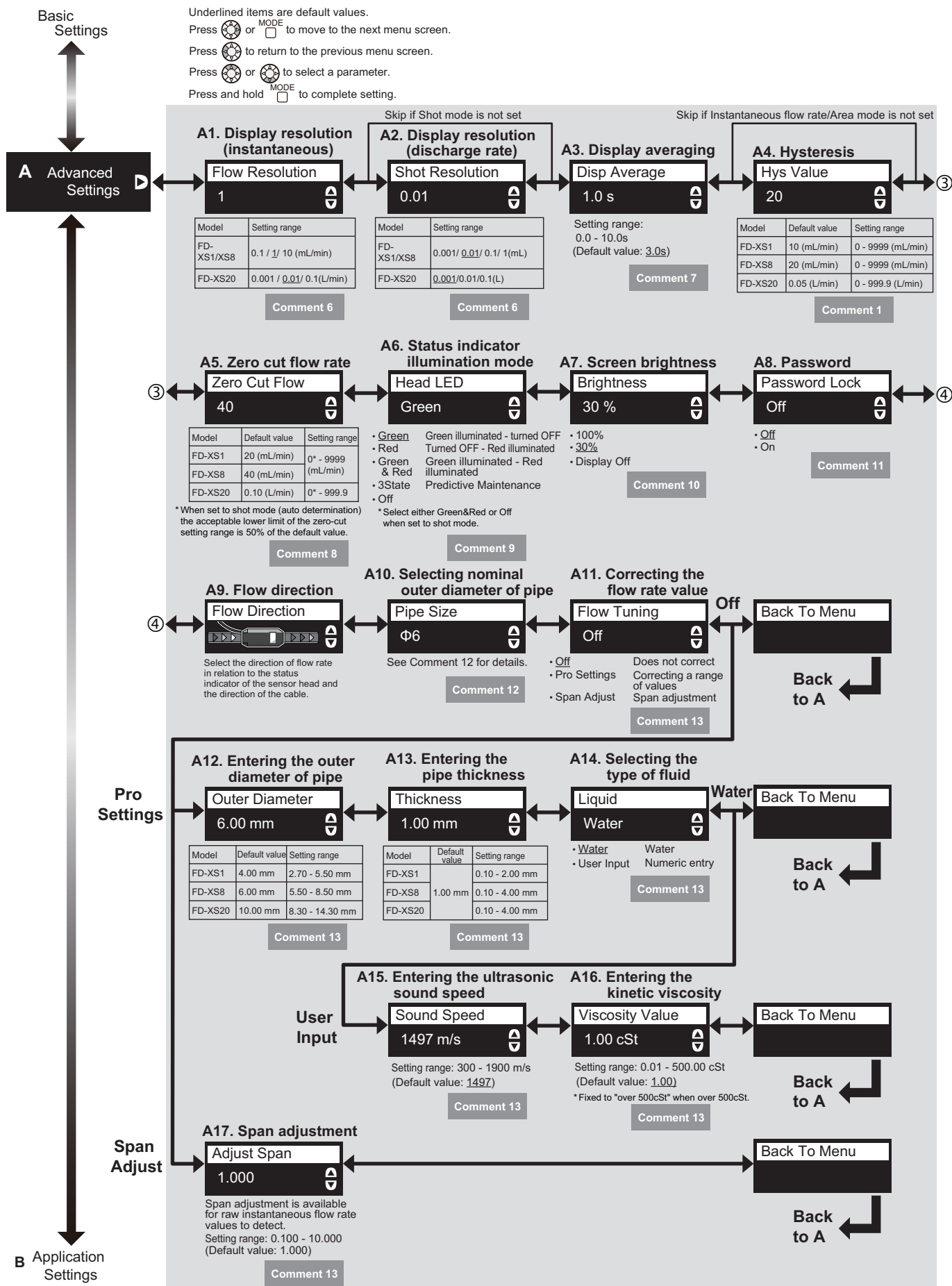
5-1 Basic settings

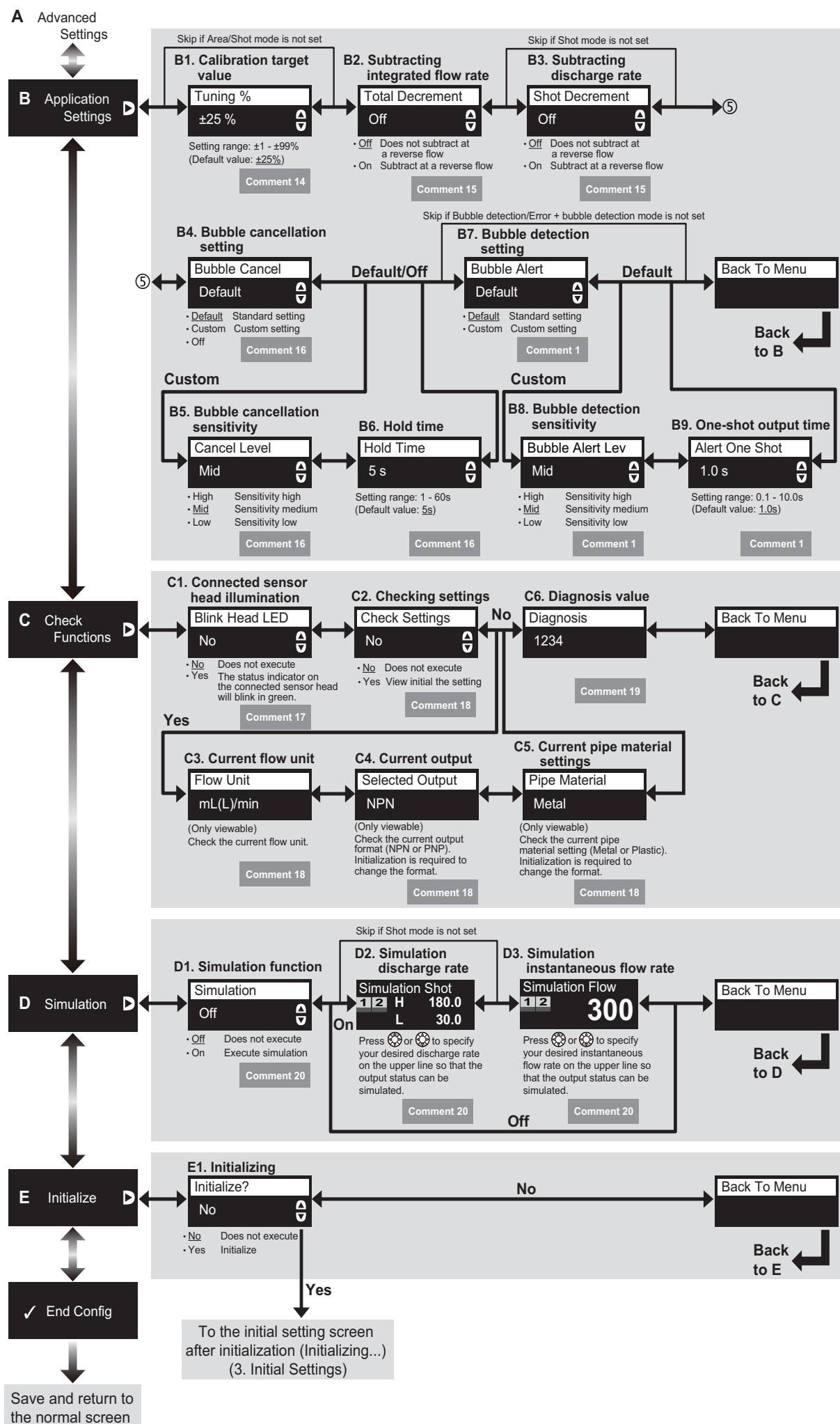
The numbers after each "Explanation" correspond to those in "6-1 Explanation of Functions".



5-2 Advanced settings

The "Comment" numbers below each setting correspond to those in "6-1. Explanation of Functions".





6 Explanation of Settings

6-1 Explanation of Functions

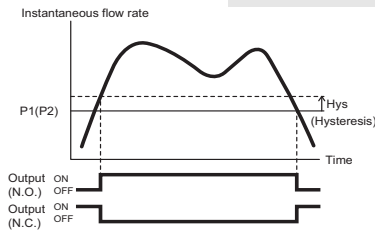
Comment 1 Detection mode

■ Instantaneous flow rate mode [Standard]

For ch.1 and ch.2

The output switches when the instantaneous flow rate falls below the threshold.
This mode is useful for detecting a drop in the supply flow rate.

P1(P2): Instantaneous flow rate of ch.1(ch.2)



- Reference • N.O./N.C. operation of the output can be switched in the settings. (P.7)
- Hysteresis can be adjusted in the Extended functions menu. (P.8)

■ Area mode [Area]

For ch.1 and ch.2

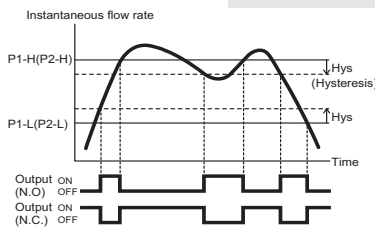
The output switches when the instantaneous flow rate deviates from a certain range.
This mode is useful for detecting excess or insufficient supply flow rate.

P1-H(P2-H):

Area high of ch.1(ch.2)

P1-L(P2-L):

Area low of ch.1(ch.2)



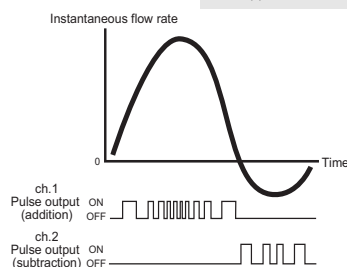
- Reference • N.O./N.C. operation of the output can be switched in the setting. (P.7)
- Hysteresis can be adjusted in the Advanced settings menu. (P.8)

■ Pulse output mode [Pulse(+)] [Pulse(-)]

Pulse(+) in ch.1
Pulse(-) in ch.2

One pulse is generated for each integrated flow unit.
This mode is useful for managing/viewing fluid usage by incorporating it with an external device such as a counter or touch panel.

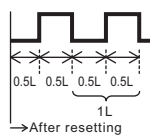
As forward and reverse direction pulses can be assigned to ch.1 and ch.2 respectively, by subtracting the ch.2 pulse count from the ch.1 pulse count, the net flow rate can be displayed externally taking the reverse flow into account.



The integrated flow unit is configurable. "11. Integrated flow unit" (P.7)

Mode	Assigned ch.	Description
Pulse(+)	ch.1	Pulse is generated based on flow moving in the forward direction.
Pulse(-)	ch.2	Pulse is generated based on flow moving in the reverse direction (reverse flow).

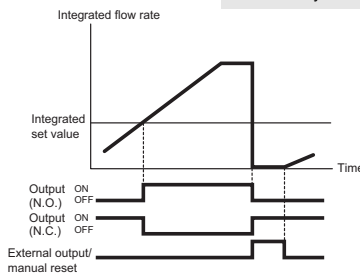
- Reference • The output pulse turns ON/OFF every half value of the integrated flow unit.
(Right figure: Integrated flow unit is set to 1L)



■ Integrated flow mode [Total]

For ch.1 only

The output signals when the integrated flow reaches the threshold value.
This mode is useful for detecting when a certain amount of flow has passed.

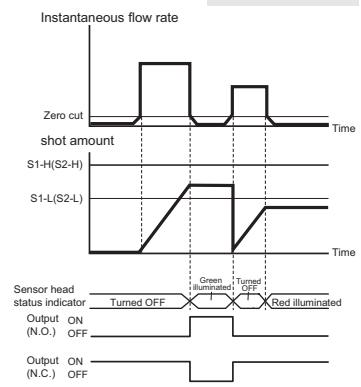


- Reference • "FFFF" is shown when the integrated flow value exceeds the upper limit of the displayable range.
- The integrated flow value can be reset by setting the function of input 2 to "Reset Total".
- When the integrated flow reset input signal is sent, the integrated flow value is reset to 0.
- The minimum input period is 20ms.
- The display depends on the integrated flow unit. (Example) When the integrated flow unit is 0.1mL and the integrated flow is 15mL, "150" is displayed.

■ Shot mode [Shot]

For ch.1 and ch.2

This mode switches the output if the discharge/shot amount falls inside the set upper and lower limits.
This mode is useful for determining if the discharge amount is within the appropriate range.



● Automatic determination (default)

Output is determined after the completion of a discharge/shot (when the instantaneous flow rate drops below the zero cut flow rate).
The shot amount is automatically reset to zero at the start of the next discharge/shot (when the instantaneous flow rate exceeds the zero cut flow rate). OK/NG can be determined for each shot without PLC programming.

Ensure the instantaneous flow rate exceeds the zero-cut flow rate in shot mode.

S1-H(S2-H): Upper limit of ch.1(ch.2)

S1-L(S2-L): Lower limit of ch.1(ch.2)

- Reference • In the case of automatic judgment, please leave at least 100 ms from the completion of one discharge to the start of the next discharge.
- If the next discharge is not started even after 30 seconds have elapsed from the discharge completion, the discharge amount and output determination will be reset.
- If you set the zero cut flow rate to a small value, the instantaneous flow rate may unexpectedly exceed the zero cut flow rate, resulting in false determination. In this case, frequently perform the origin adjustment or the zero shift input, or change to "Manual determination".

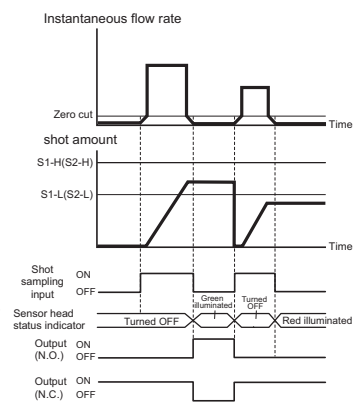
● Manual determination

When "Shot Sample" is selected for the function of input 1, the sensor performs the determination assuming that the period where there is an external input is the discharge period.

1. The shot amount is reset when the external input is turned ON, and starts detecting.
2. Determination is done when the external input turns OFF.

This ensures correct determination even when the zero cut value is smaller than the default value.

Use when the instantaneous flow rate is lower than the zero cut value.



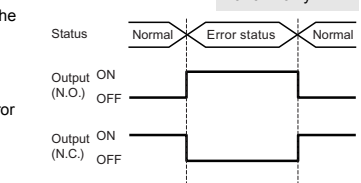
- Reference • You can also use the zero shift input of input 2 at the same time. Accurate detection is possible while periodically correcting the origin by performing the zero shift when there is full fluid and discharge has stopped.
- When Shot Sample is assigned to input 1, multi shot tuning is not possible.

■ Error output mode [Error]

For ch.2only

An output is generated when any of the following errors occur.

- Head Error Sensor head error
- EEPROM Error EEPROM Error
- rEv Reverse flow error
- --- Detection impossible error



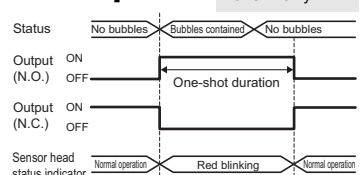
- Reference • For details on errors, see "10 Troubleshooting" (P.17).

■ Bubble detection mode [Bubble Alert]

For ch.2only

This mode can detect and output sudden drop of ultrasonic signal when bubbles pass.

Sensitivity of the bubble detection can be selected from High (most sensitive), Mid, and Low (less sensitive).
Output is one shot; the one shot time is configurable.



- Reference • The size of the bubbles that can be detected depends on the piping, fluid, and flow speed. Please test and validate the actual detectable bubble level in the field. (Reference: When PFA pipe is φ8 (inner diameter of φ6), the fluid is water and the flow rate is 0.1 m / s, bubbles with approx. φ3 (High) / φ4 (Mid) / φ5 (Low) can be detected.)

■ Error + bubble detection mode [Error+Alert]

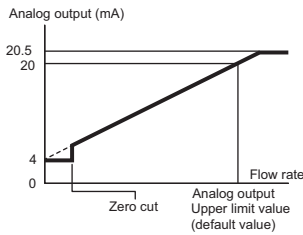
For ch.2only

An output is generated when the condition for either "Error output mode" or "Bubble detection mode" is met.
This is useful when you want an output to be generated on a single output wire for both bubbles and errors.

Comment 2 Analog output

You can set the flow rates that correspond to the upper and lower limits of the analog output. Analog output can be selected from 4-20mA or 0-20mA. (Below is an example when 4-20mA is selected)

Initial state (default values)

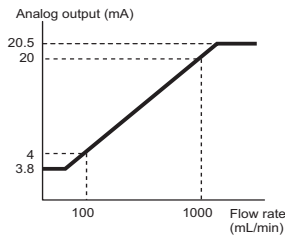


Model	Upper limit value (default value)
FD-XS1	1000 mL/min
FD-XS8	8000 mL/min
FD-XS20	20.00 L/min

When the settings are changed

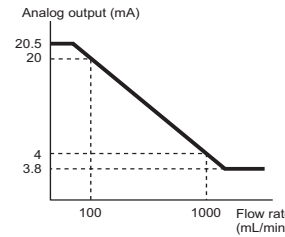
Example 1

Analog output upper limit value	1000 (mL/min)
Analog output lower limit value	100 (mL/min)



Example 2

Analog output upper limit value	100 (mL/min)
Analog output lower limit value	1000 (mL/min)



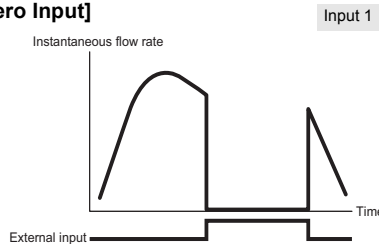
- When there is a sensor head error, reverse flow error, or detection impossible error, the analog output becomes 3.5mA (when 4-20mA is set) or 0mA (when 0-20mA is set).
- The analog output is updated every 30ms or sooner.

Comment 3 External input

Flow rate zero input [Zero Input]

While the external input is ON, the instantaneous flow rate is forced to zero.

This is useful for zeroing flow rate display or preventing an output at an unexpected time, such as when the pipe is not full of fluid.



- The minimum input period is 20ms.
- While there is an input, the analog output corresponds to 0mL/min and the integrated flow/shot amount is not counted up.

Shot sampling input [Shot Sample]

By selecting this, the shot mode becomes manual determination. For details, see "Manual determination" (page10) in Shot Mode.

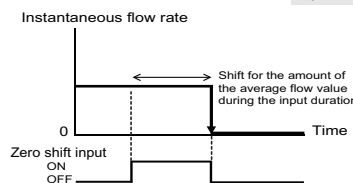
Integrated flow reset input [Reset Total]

This resets the integrated flow display to zero. When the integrated flow reset input signal is sent, the integrated flow display is reset to 0. For details, see "Integrated flow mode" (page10).

Zero shift input [Zero Shift]

This shifts the average flow rate during the zero shift input period to zero.

Especially in the shot mode, long-term and stable detection is achieved by utilizing the zero shift input each time the fluid is still between shots.



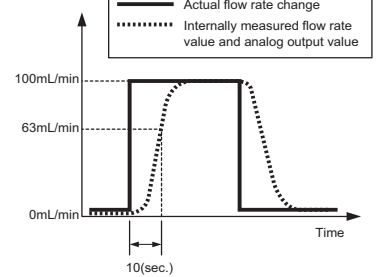
- The minimum input period is 20ms.
- "Error" is shown when the zero shift has failed.
- Turning off the power resets the shift status.

Comment 4 Response time

The response time is the time required for the internal evaluation value and the analog output to register/display at least 63% of the change in the instantaneous flow rate.

Example:

Assuming that the response time is 10 seconds and the actual flow rate instantaneously rises from zero to 100mL/min, the instantaneous flow rate of the sensor rises to 63mL/min, which is 63% of 100mL/min, within 10 seconds.



Comment 5 Integrated flow unit

The Integrated Flow Unit is the amount of flow represented by every single digit increase of the Integrated Flow Value.

Comment 6 Display resolution

You can change the display resolution. In shot mode, you can separately set the display resolution for the shot amount.

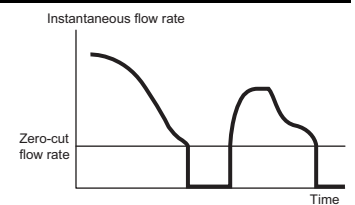
Comment 7 Display averaging

This function averages the instantaneous flow rate value and displays it. As this setting becomes larger, the display becomes more stable.

- Display averaging only affects the display of the instantaneous flow rate. It does not affect the determination of control output/analog output, shot display or full-time recording function.

Comment 8 Zero cut flow rate

If the instantaneous flow rate is within a certain area, the sensor is forced to recognize the instantaneous flow rate as 0. This value is called the "Zero cut flow rate". When the zero cut flow rate is turned OFF, the zero cut is not performed and a negative value is displayed in the case of reverse flow (rEv).

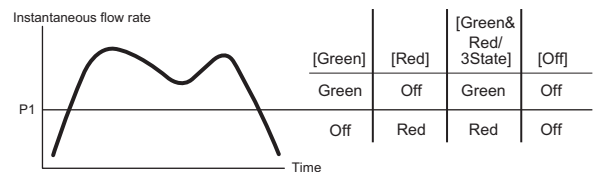


- While the instantaneous flow rate is below the zero cut flow rate, the control output, analog output and Integrated flow behave as if there is no flow.
- If a flow rate exceeding the zero cut flow rate flows to the negative side (reverse flow side), a negative value will be displayed.
- The minimum value of zero cut range for Shot mode (Automatic determination) is 50% of the default zero-cut value.

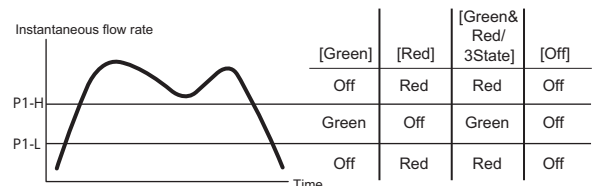
Comment 9 Status indicator illumination mode

When the function of ch.1 is set to "Instantaneous flow rate mode" or "Area mode", you can specify the illumination mode of the status indicator. The illumination is linked to the setting P1 (P1-L/P1-H) of ch.1.

Instantaneous flow rate mode



Area mode

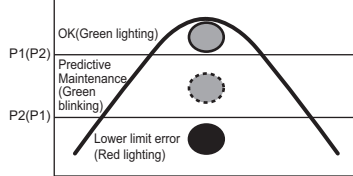


- The status indicator is not affected by the output logic N.O./N.C.
- When ch.1 is in shot mode, only "Green & Red" or "Off" (always off) can be selected. For the behavior when "Green & Red" is selected, see Shot mode on page 10.
- When ch.1 is in the pulse output mode or integrated flow rate mode, the indicator behaves in conjunction with the zero cut flow rate and not with the P1(P1-H/P1-L) value of ch.1.
- When ch.2 is in the bubble detection mode or error + bubble detection mode, the status indicator turns on red while the bubble detection output is ON.

■ Predictive Maintenance Indicator (PMI) (3State)

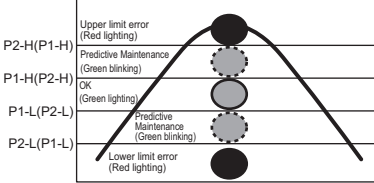
If "3State" is selected and any of the following conditions are fulfilled, the large status indicator can be used as a PMI.
1) Both ch.1 and ch.2 are in the "Instantaneous flow rate mode"
2) Both ch.1 and ch.2 are in the "Area mode"

When both ch.1 and ch.2 are in the "Instantaneous flow rate mode"



Reference If the flow rate value exceeds both P1 and P2, the status is green. If it is between P1 and P2, green blinking. If it falls below both P1 and P2, red.

When both ch.1 and ch.2 are in the "Area mode", configure the sensor so that the area of ch.1 is within the area of ch.2.



Reference The indicator turns on green if the flow rate is within the areas of both ch.1 and ch.2, blinks green if it is only within the area of ch.2, or turns on red if it is not within either areas.

Comment 10 Screen brightness

This determines the illumination level of the screen when buttons are not pressed for a certain period of time.

Item	Description
100%	The OLED display brightness is always 100%.
30% (Default)	The OLED display brightness is reduced to 30% after a certain period of time.
Display Off	The OLED display turns off after a certain period of time.

- Brightness of the OLED display decreases when using the FD-X Series for a long period of time.
- Setting [100%] leads to the speed-up of the decrease in the OLED display brightness.
- When [Display Off] is selected, only the 7-segment display shows the following.



*Pressing a button restores the previous display state.

Comment 11 Password

When set to [On], you can set a PIN code for releasing the "7-2. Key Lock" (page 14). Acceptable range is "0 - 9999".

Comment 12 Selecting nominal outer diameter of pipe

The FD-X series internally stores the parameters corresponding to the following outer diameters of pipes, and calculates the flow rate based on the selected nominal outer diameter of pipe.

FD-XS1	FD-XS8	FD-XS20
φ3 φ4 1/8"(3.18mm)	φ6 φ8 1/4"(6.35mm)	φ10 φ12 3/8"(9.53mm) 1/2"(12.7mm) 6A(10.5mm) 8A(13.8mm)

Comment 13 Flow Rate Tuning

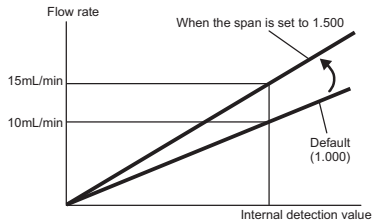
This feature can be used to correct the instantaneous flow rate if you want to increase the accuracy of detecting the flow rate.

- If you know the actual instantaneous flow rate, then correction using Span Adjust is most effective.
- If you know the information on the fluid and pipe, then correction using Pro Settings is effective.

Reference If you know the actual shot amount using an electronic scale or other methods, you can enter the measured value in "7-4. Target calibration" (page 14), to automatically adjust the span.

■ Flow rate span adjustment [Adjust Span]

You can adjust the span from 0.100 to 10.000 times of the internal detected value.



■ Correction of values [Pro Settings]

Detected value can be corrected by entering the size of the pipe and the characteristic of the fluid being detected.

● Size of the pipe

The FD-X series calculates the flow rate based on the following internal parameters depending on the "Selecting nominal outer diameter of pipe" setting.

FD-XS1		FD-XS8		FD-XS20	
Nominal outer diameter of pipe	Thickness (mm)	Nominal outer diameter of pipe	Thickness (mm)	Nominal outer diameter of pipe	Thickness (mm)
φ3	0.75	φ6	1.00	φ10	1.00
φ4	1.00	φ8		φ12	1.00
1/8"(3.18mm)	0.80	1/4"(6.35mm)		3/8"(9.53mm)	1.60
				1/2"(12.7mm)	1.60
				6A(10.5mm)	2.00
				8A(13.8mm)	2.30

If the outer diameter or thickness of the pipe that is actually used differ from above, the flow rate can be corrected by entering the actual values (Outer Diameter / Thickness).

● Characteristics of the fluid being detected

The FD-X series calculates the flow rate assuming that the fluid being detected is water. If the fluid being detected is not water and you know the propagation velocity of ultrasonic waves and kinematic viscosity, the detection accuracy can be improved by entering these values.

Sound Speed: Enter the velocity of ultrasonic waves in the fluid being detected.

Typical data is as follows:

Fluid	Velocity of ultrasonic waves (m/s)	Fluid	Velocity of ultrasonic waves (m/s)
Water (25°C)	1497	Water soluble coolant	1490
Lithium grease	1400	Oily coolant	1250

Viscosity Value: Enter the kinematic viscosity of the fluid being detected.

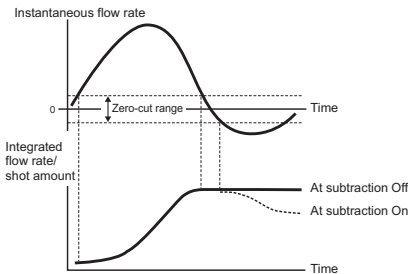
Comment 14 Calibration target value

When calibrating the sensor, you can determine the ± percentage which automatically sets the range for upper/lower limits.

- Upper/lower limits when the full auto calibration is performed when the detection mode is set to area mode
- Upper/lower limits when the full auto calibration is performed when the detection mode is set to shot mode
- Upper/lower limits when the multi-shot calibration is performed when the detection mode is set to shot mode

Comment 15 Subtracting the integrated flow/shot amount

You can configure if the integrated flow and shot amount should be subtracted from when the instantaneous flow rate is below 0mL/min (reverse flow). Default is Off (not subtracted).

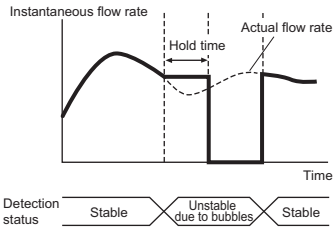


Reference The value is also subtracted based on the reverse flow rate when the reverse flow error occurs and the feature is set to On (subtracted).

Comment 16 Bubble cancellation feature

Set a period of time to hold the last display status and output status when the FD-X series fails to receive the ultrasonic signal. This is useful when bubbles make detection unstable.

The level of the detectable bubble can be selected from High (most sensitive), Mid, and Low (less sensitive).



- Reference
- The instantaneous flow rate, control output, internal determination value, and analog output value right before the hold period is kept while in hold. Shot amount and integrated flow is not incremented during the hold.
 - When the state recovers from instability due to bubbles before reaching the hold period duration, the hold is released and reverts to the normal state.

Point The size of the bubbles that can be canceled depends on the piping, fluid, and flow speed. Please test and validate the actual detectable bubble level in the field.

Comment 17 Connected sensor head illumination

While "Connected sensor head illumination" is turned on, the status indicator for the sensor head connected to the controller blinks green. This is useful to determine the sensor head being configured when you are using multiple sensor heads.

Comment 18 Checking settings

You can check the current flow unit, NPN/PNP selection, and pipe material settings. These settings cannot be changed in this section.

Comment 19 Diagnosis value

When the displayed diagnosis value is not stable, the detecting condition may be unstable.

Comment 20 Simulation function

You can check the sensor output or indicator function by entering any instantaneous flow rate or shot amount to simulate a fluid flow with that value. This is useful for checking the wiring and functionality before actual flow begins.

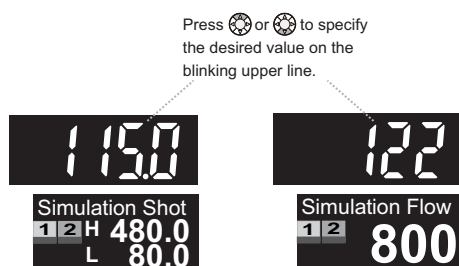
● Items that change based on the simulation flow rate

1. Output decision of output 1 and 2
2. Output indicators on the controller
3. Analog output value
4. Pulse output
5. Sensor head status indicator

Reference • This feature does not affect the integrated flow rate or the recording data in the full-time recording feature.
• External input is disabled in the simulation mode.

■ Simulation screen for shot amount

■ Simulation screen for instantaneous flow rate



6-2 Settings for accurate detection of the shot amount

The settings explained below are recommended to detect the shot amount more accurately.

(1) Perform the origin adjustment (page 14).

Correct the origin after installing the unit on a pipe.

(2) Configure functions.

Use the shot mode that can set a threshold for each amount and make OK/NG judgment. With the zero shift input through an external input, an origin's shift over time can be corrected.

Setting items	Setting values	Setting methods	Comment number*1
ch.1 detection mode	Shot mode	Page 7	Comment 1
Selecting input 1 function	Discharge sampling input	Page 7	Comment 3
Selecting input 2 function	Zero shift input	Page 7	Comment 3
Response time	50ms	Page 7	Comment 4
Display resolution (discharge rate)	Lower the value if necessary	Page 8	Comment 6
Zero cut flow rate	Around 0mL/min*2	Page 8	Comment 8
Subtracting discharge rate	On	Page 9	Comment 15

*1 Comment numbers corresponds to those of "6-1 Explanation of Functions".

*2 When the zero cut flow rate is set to zero completely, it is recommended to set it to a constant rate such as 3 mL / min because slight variation factor leads to discharge error.

(3) Perform the target calibration (page 14).

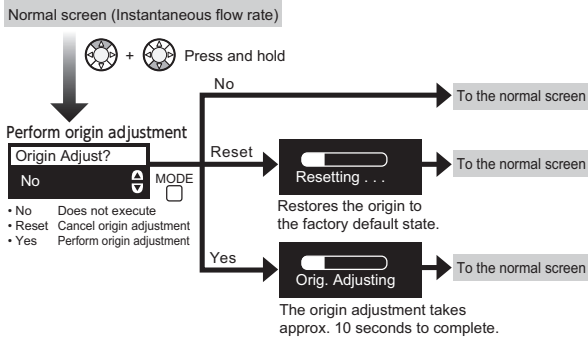
The span is optimized based on the value of the shot amount.

7 Useful Functions

7-1 Origin Adjustment

This function sets the instantaneous flow rate at the time of performing the origin adjustment as "zero". Perform the origin adjustment after completing the installation and initial settings.

Point Perform this function when the pipe is filled with fluid and the fluid is not moving.



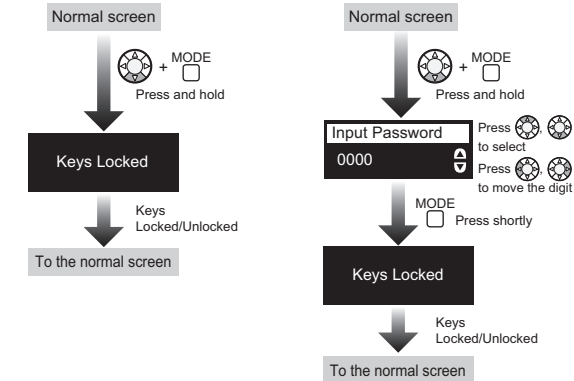
Reference If the FD-X series fails to adjust the origin, it shows "Error" and goes back to the normal screen.

7-2 Key lock

This function prevents operation mistakes by locking/disabling key operations. This is effective when you do not want the settings to be easily changed. If you want to require a password for releasing the key lock, turn on the password in the advanced settings as described in "A.8 Password".

Locking/unlocking keys Locking/unlocking keys with PIN

(Turn on the "password" in the advanced settings)

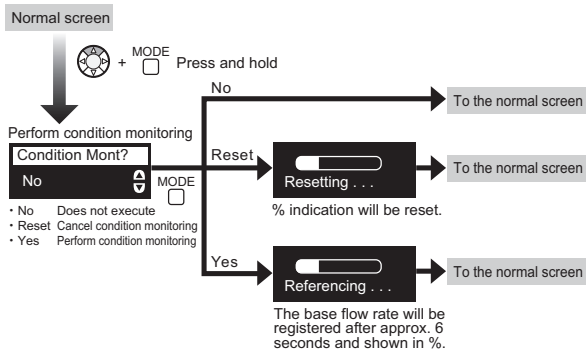


Reference If an incorrect PIN is entered, the FD-X series shows the "Password Error" message and goes back to the normal screen with keys locked.

7-3 Condition Monitoring Function

This is a feature to register the instantaneous flow rate at the time of performing the condition monitoring function as 100%, and to display the value relative to the base flow rate. It is effective when you want to check the degree of change relative to the base flow value.

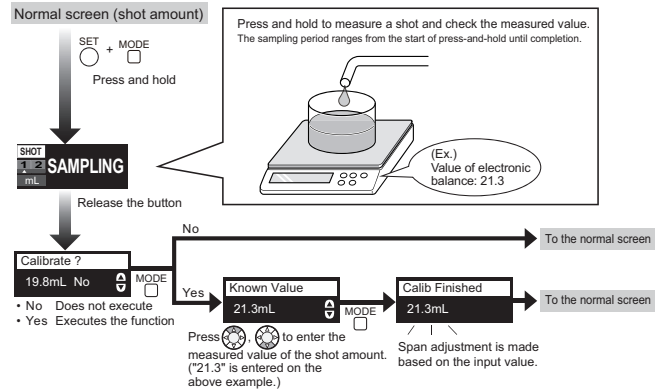
- Point**
- Perform the Condition monitoring function when the fluid is flowing at a nominal rate that you would like to have represented as 100%.
 - The setting is linked to the instantaneous flow rate setting for ch.1.



Reference The Condition monitoring function is effective only for the instantaneous flow rate value and its threshold. When performed at a low flow rate, the display may become unstable. If the FD-X series fails to register the base flow rate, it shows "Error" and goes back to the normal screen.

7-4 Target calibration (for the shot mode)

This feature is used to adjust the flow rate detected by the sensor to a measured value to optimize the internal span when the actual shot rate is known. It is possible to optimize the span value based on the measured value even when the ultrasonic sound speed in fluid or outer diameter and thickness of the pipe are not known.

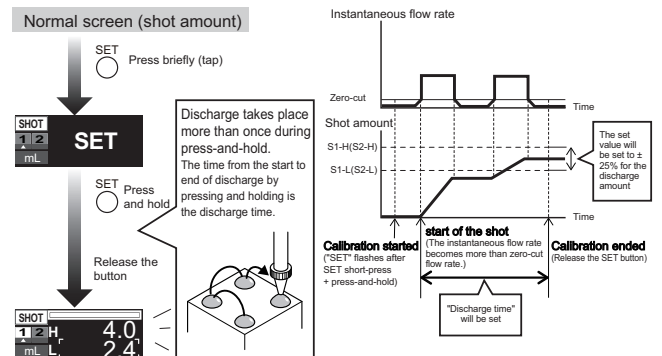


- Reference**
- If the FD-X series fails to calibrate the target, it shows "Error" and goes back to the normal screen.
 - During the target calibration, "A17. Span adjustment" (page 8) and "A5. Zero cut flow rate" (page 8) are automatically adjusted based on the detected value and measured value entered.
 - When "Pro Settings" is selected for "A11. Correcting the flow rate value" (page 8), the target calibration will be failed (Error).
 - While "manual determination" is activated for the shot mode, the target is set to the flow rate detected in the following condition: pressing and holding the SET and MODE buttons simultaneously, and the shot sampling input is on.

7-5 Multi-shot calibration (for the shot mode)

In this mode, the system determines pass/fail for the total shot amount in a cycle if there are multiple shots in one cycle.

- It is effective when you want to check the degree of change relative to the base flow value.
- After tuning, accumulates the discharge amount until the "discharge time" elapses after the instantaneous flow rate exceeds the zero cut flow rate, and judges the output.



The upper/lower limit setting values are subtracted to $\pm 25\%$ for the discharge amount during discharge time.

* A ratio of $\pm 25\%$ can be changed in "S-2 B1. Tuning target value" (page 9).

Point

The screen after the multi shot calibration

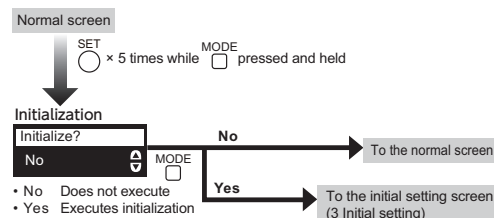
The bar at the top shows the "discharge time". The bar progresses from the start to end of the discharge time, and the output is determined at 100%.



- Reference**
- If the FD-X series fails the multi-shot calibration, it shows "Error" and goes back to the normal screen.
 - If shot sampling input is selected in the external input function, the multi-shot calibration is not possible.
 - To release the multi-shot calibration, perform the full auto calibration or initialization.
 - The valid discharge time for the multi-shot calibration is up to 99 seconds.

7-6 Initializing

This restores the settings to factory defaults.



Reference The recording data is not initialized.

8 Full-time recording

The FD-X series continuously records the data for previous "instantaneous flow rates", "shot amounts", "events" and "Accumulated flow". It is useful to check whether the discharge amount is changing with time, or to analyze what happened when troubles such as flow abnormality occurred.

8-1 Data to be recorded

■ Shot mode not set

Type	Meaning	Recording intervals	Amount of data to be stored
Max./min. instantaneous flow rate	Maximum (P: peak) and minimum (B: bottom) instantaneous flow rates during a certain period of time.	Variable (1 min/5 min (default)/10 min/60 min)	Approx. 4000 records (Approx. two weeks with 5-minutes' interval)
Integrated flow amount	Integrated flow rate from power on.		
Event	Events that occurred during a certain period of time.		

■ Shot mode set

Type	Meaning	Recording intervals	Amount of data to be stored
Max./min. instantaneous flow rate	Maximum (P: peak) and minimum (B: bottom) instantaneous flow rates during a certain period of time.	Variable (10 shots/50 shots (default)/100 shots)	Approx. 4000 records (Approx. one week with 50-shots interval, shot cycle of 3 seconds)
Integrated flow amount	Integrated flow amount from power on.		
Event	Events that occurred during a certain period of time.		
Shot amount of each individual	Shot amount of each individual shot (each cycle during the multi-shot calibration)	Saved per shot	Approx. 21500 shots (18h with the shot cycle of 3 seconds)

- Reference
- Recording intervals can be changed through the settings. See "F5. Recording frequency" in "8-3. Full-time recording advanced settings".
 - Below are displayed in the "Event" screen.

Event	OLED display	Event	OLED display
No event	NO EVENT	Reverse flow error	REVERSE FLOW
EEPROM error	EEPROM ERROR	Cannot detect	STABILITY 0
Over current error	OVER CURRENT		STABILITY 1
Head error	HEAD ERROR		STABILITY 2
Output1 ON *1	OUTPUT1 ON	Change in stability	STABILITY 3
Output1 OFF *1	OUTPUT1 OFF		STABILITY 4
Output2 ON *1	OUTPUT2 ON	Bubble detected *2	BUBBLE ALERT
Output2 OFF *1	OUTPUT2 OFF		

*1 Not recorded in pulse-output mode/integrated flow mode/shot mode.

*2 Displayed when a bubble is detected regardless of the detection mode setting.

8-2 Screen for checked the recorded data

Current value on the normal screen

Full-time recording screen

Press (or) + MODE press and hold

Press to move to the next data

Press and to switch the display Press to return to the previous data

■ If shot mode is not set

Elapsed time since power-on is shown at the top right corner.
Example: When the recording frequency is 5 min., "000:25" means "the time period of greater than equal to 25 minutes and below 30 minutes after power on".

Maximum/minimum instantaneous flow rate	Integrated flow	Event
CD HOLD 000:30 P 148 B 0	CD TOTAL 000:30 (unit 1) 147	CD EVENT 000:30 OUTPUT1 OFF
CD HOLD 000:25 P 139 B 0	CD TOTAL 000:25 (unit 1) 58	CD EVENT 000:25 NO EVENT

■ If shot mode is set

Number of shots since power-on is shown at the top right corner.
Example: When the recording frequency is 50 shots, "251-" means "period of greater than or equal to 251 shots and below 301 shots after power on".

Maximum/minimum instantaneous flow rate	Individual shot rate	Integrated flow	Event
CD HOLD 301- P 0.9 B 0.1	CD ALL 300 3.0	CD TOTAL 301- (unit 1) 41	CD EVENT 301- REVERSE FLOW
CD HOLD 251- P 3.6 B 0.1	CD ALL 299 3.1	CD TOTAL 251- (unit 1) 31	CD EVENT 251- NO EVENT
	CD ALL 251 3.3		

Point Recorded data may thin out when the shot interval is under 3 seconds in shot mode (this does not affect normal output determination operation).

8-3 Full-time recording advanced setting

- Underlined items are default values.

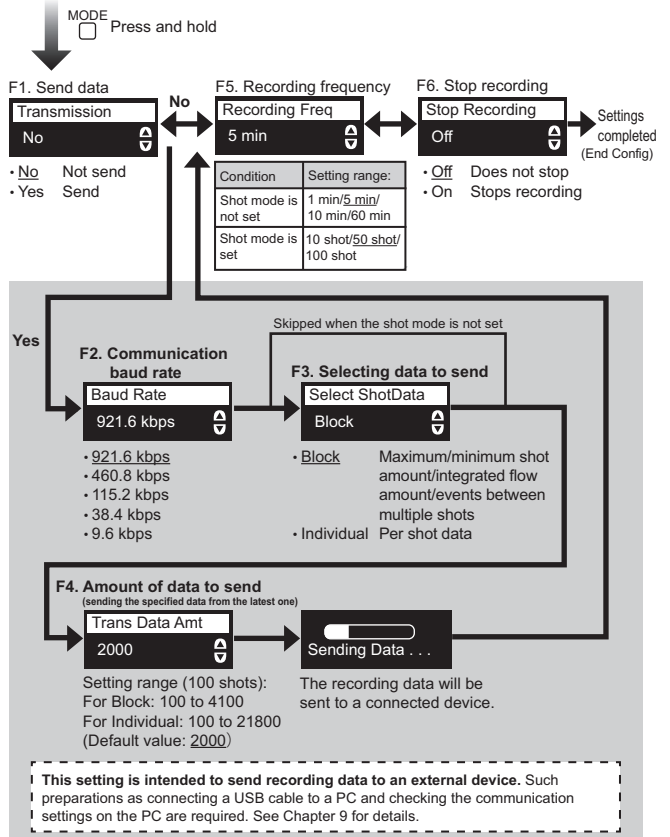
Press or MODE to move to the next menu screen.

Press to return to the previous menu screen.

Press or to select a parameter.

Press and hold MODE to complete settings.

Full-time recording screen

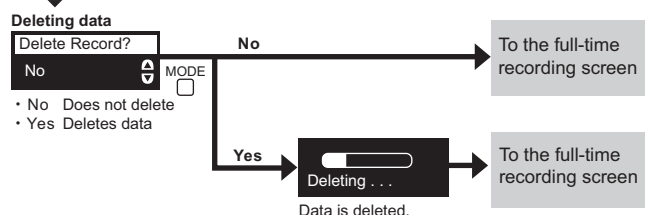


8-4 Deleting the recorded data

It is possible to delete all the recorded data stored in the FD-X series. It is useful to initialize the recorded data.

Full-time recording screen

SET × 5 times while MODE is pressed-and-held



9 USB Communication (Recorded Data Output)

The FD-X series can transmit the data accumulated by the full-time recording feature in Chapter 8 to external devices such as a PC via USB communication. This is useful when you want to check the data from a long period of time or to generate a chart using a spreadsheet software.

9-1 Communication specifications

Item	Specifications
Communication method	Full-duplex
Synchronization	Start-stop synchronization
Transmission code	ASCII
Communication speed	Selectable
Data bit length	8 bit
Parity check	Even
Stop bit length	1 bit
Data delimiter	Fixed to CR+LF

9-2 Preparation

■ Downloading the dedicated USB driver

You can download the USB driver from KEYENCE's home page.

www.keyence.com/global.jsp

If you are using the system in an environment where you cannot download the software via the internet, please contact your local KEYENCE office.

■ Installing the USB driver

Run "dpinst_64.exe" (64bit) or "dpinst_86.exe" (32bit) in the downloaded file.

Then, follow the instruction in the installation program.

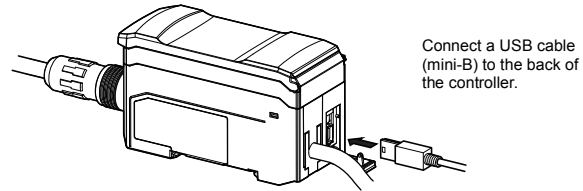
When you successfully complete the installation, the following software is installed.

- USB driver <KEYENCE CORPORATION USB-COM [FD Series]>

● Supported OS

- Windows10/8/7/Vista/Server 2003/XP/2000

9-3 How to connect



Connect a USB cable (mini-B) to the back of the controller.

- Reference • You can use either OP-51580 (USB cable 2 m) or OP-86941 (USB cable 5 m).

9-4 Transmission data format

When you run "F1. Data transmission" in "8-3. Full-time recording advanced setting" (P.15), the FD-X series automatically sends the data based on the ASCII code.

- Reference
- Each data is delimited by a comma (,).
 - The transmitted data consists of the header section and subsequent data sections.
 - The header section and each data section is followed by a carriage return (CR+LF).
 - The instantaneous flow rate/shot amount data is sent according to the current resolution setting.

■ Basic format

The format falls in to two patterns depending on the detection mode and the transmitted data.

Detection mode	Transmitted data	Format pattern
Shot mode	Block*	A
	Individual*	B
Others	-	A

*Can be selected at "F3. Selecting transmission data" (P.15).

A

Column	1st column	2nd column	3rd column	4th column	5th column	6th column	7th column	8th column	9th column	10th column	11th column
Meaning	Data type*1	Elapsed time/ number of shots	Peak value	Bottom value	Integrated flow rate*2	EEPROM error	Over current error	Head error	Cannot detect	Reverse flow error	Output1 ON
Header section	TYPE,	OPERATION TIME/COUNT,	PEAK,	BOTTOM,	TOTAL (unit *),	ERE,	ERC,	ERH,	STAB_0,	REV,	CH1_ON,
Example of the data section	F,	0:10,	125,	123,	2013,	1,	0,	0,	0,	0,	0,
	F,	0:5,	122,	120,	1698,	0,	1,	0,	0,	0,	0,
	F,	0:0,	102,	98,	1602,	0,	0,	1,	0,	0,	0,
	S,	101,	12.5,	12.2,	1203,	0,	0,	0,	1,	0,	0,
	S,	51,	13.1,	12.5,	803,	0,	0,	0,	0,	1,	1,
	S,	1,	13.8,	13.0,	392,	0,	0,	0,	0,	0,	0,

12th column	13th column	14th column	15th column	16th column	17th column	18th column	19th column	20th column	21st column	22nd column	23rd column
Output1 OFF	Output2 ON	Output2 OFF	Change in stability				Bubble detected	(Not used)		Checksum	Line break
CH1_OFF,	CH2_ON,	CH2_OFF,	STAB_1,	STAB_2,	STAB_3,	STAB_4,	BUBBLE,	RESERVED,	RESERVED,	CHECKSUM	[CR+LF]
0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	225	[CR+LF]
0,	0,	0,	1,	0,	0,	0,	0,	0,	0,	156	[CR+LF]
0,	0,	0,	0,	1,	1,	0,	1,	0,	0,	15	[CR+LF]
1,	0,	1,	0,	0,	0,	0,	1,	0,	0,	21	[CR+LF]
0,	1,	0,	0,	0,	0,	1,	0,	0,	0,	92	[CR+LF]
0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	151	[CR+LF]

*1 When the data type is F, the 2nd column shows the elapsed time after power on, and the 3rd and 4th columns show the peak/bottom values of the instantaneous flow rate. When the data type is S, the 2nd column shows the shot count after power on, and 3rd and 4th columns show the peak/bottom values of the shot amounts.

*2 The "" for "TOTAL (unit *)" indicates the integrated flow rate unit at data transmission. Example: When the integrated flow rate unit is 0.1mL and the integrated flow rate is 12mL, the header section will be "TOTAL (unit 0.1)" and the data section will be "120".

B

Column	1st column	2nd column	3rd column	4th column
Meaning	Number of shots	Shot amount	Checksum	Line break
Header section	SHOT_NUM,	SHOT_RATE,	CHECKSUM	[CR+LF]
Example of the data section	4,	12.5,	129	[CR+LF]
	3,	8.7,	90	[CR+LF]
	2,	13.0,	132	[CR+LF]
	1,	10.7,	108	[CR+LF]

Reference About the checksum

- The value of the checksum is calculated by adding each data except the delimiter (comma) and checksum of each data, and dividing it by 256 to obtain the remainder.
- Data type F is calculated as 1, and data type S is calculated as 2.
- When the data section is 12:34, it is calculated as 12+34=46.
- The flow rate is calculated without considering the decimal point.
Example: Data 12.3 -> Calculated checksum value 123
- Event is added for every 1.
Example: When only STABILITY 0 and BUBBLE ALERT occur, the checksum calculated value is 1+1=2.

10 Troubleshooting

10-1 Troubleshooting

Problem	Cause	Solution
Head Error is displayed	There is a breakage in the sensor cable or the sensor head is disconnected	- Verify that the sensor head is connected. - Check the sensor cable for damage. - Check the connection of the sensor cable to the connector. - Cycle the power.
Over Current is displayed	There is an overcurrent on control output 1 or 2	- Check if the output wires are connected correctly and are not in contact with other wires. - Check if the load is within the rated range for the outputs.
EEPROM Error is displayed	The memory has reached its end of life, or the sensor is malfunctioning.	- Perform initialization. - In addition, clear the full-time recording log data. - If the problem is not resolved, contact local KEYENCE office.
- rEv (7SEG) is displayed - Negative instantaneous flow rate is displayed	Fluid is flowing in the reverse direction as the configured flow direction, or convection is occurring	Set the flow direction according to the correct fluid flow direction.
	Origin has significantly shifted	Perform the origin adjustment when the pipe is filled with fluid and the fluid is not moving.
	The instantaneous flow rate is significantly exceeding the rated flow rate	Use the FD-X series within the range where correct values can be shown
In the integrated flow display, FFFF is displayed at the top row.	The displayable range was exceeded in the integrated flow display	- Perform the integrated flow reset. - Change the integrated flow unit to a more appropriate setting, or use an external counter.
A moving - (bar) is displayed	Display brightness is set to [Display Off]	Set the brightness of the screen to [30%]
Keys Locked is shown	Keylock function is active.	Release the keylock to change settings. If you forgot the keylock PIN, contact local KEYENCE office.
"rEC" is shown on the top row	You are on the full-time recording screen	Press MODE+right (or left) or cycle the power to go back to the current value display screen.
---- is shown		- Verify that the clamp was correctly attached. - Verify that the screws are not unevenly tightened or are not loose. - Install the sensor so that the display is perpendicular to the ground, not parallel. - Remove the sensor head and clamp from the pipe, and attach them at different location. - If there is rust or dirt on the surface of the pipe, shift the sensor head position. - If there is a seam on the contact surface of the sensor head or the back of the pipe, shift the sensor head position. - If bubbles or foreign matters are expected inside the pipe, change the installation location, or remove them through high-pressure washing. - If the special rubber has deformed, contact local KEYENCE office. - Increase the response time. - Set the hold time to a longer value. - If the problem persists, then the fluid or the pipe may be causing detection issues, or the flow sensor may be damaged.
- Occasionally "0" L/min(G/min) is displayed. - Two or one stability indicators turn on - One stability indicator blinks.	- Clamp is not correctly attached - The sensor head is not correctly attached to the clamp - The pipe is not filled with fluid. - The detection signal is unstable. - The special rubber attached to the clamp has deformed - The sensor is affected by pulsation or bubbles.	
	The pipe is not filled with fluid.	Install the sensor so that the display is perpendicular to the ground, not parallel.
	The sensor is affected by pulsation or bubbles.	Increase the response time.
	Cavitation is occurring due to pressure changes.	Set the hold time to a longer value.
Instantaneous flow rate is unstable	Flow rate distribution is uneven over time	- Increase the response time. - Install the FD-X series on a straight part of the pipe if possible - Avoid installing just after a bore conversion section or a bulb.
	The FD-X series is affected by a noise	Increase the response time.
	The FD-X series is affected by a vibration	- Increase the response time. - Implement an anti-vibration measure such as supporting the pipe.
	The pipe material attached a sensor head does not match the pipe material selection setting	Make sure that the pipe material attached a sensor head matches the pipe material selection setting.

Problem	Cause	Solution
Instantaneous flow rate does not change from zero	You are in the integrated flow display mode or on the shot display screen	Press the MODE button to switch the display, and verify that you are not in the integrated flow display mode or in the shot display mode.
	When using the external input function, the flow rate zero input (Zero Input) is selected, and the external input is ON.	- Check if the wiring arrangement is correct. - If the input wire and output wire are in contact, separate them. - If the flow rate zero input (Zero Input) has been set accidentally, select a different option.
	No flow.	Check valves for open and close conditions, and also check the pipe and filter for clog.
	The fluid is actually flowing, however, with a flow rate value less than the zero cut flow rate.	Adjust the zero cut flow rate.
	Flow direction is not correct	If there is a slight reverse flow, the FD-X series shows 0 instead of rEv (7SEG). Set the zero cut flow rate to OFF and check the behavior.
The value is significantly different from the measured flow rate or actual flow rate values	Installation is not correct	Verify that the sensor head was correctly attached.
	The diameter or thickness of the pipe selected in the settings does not match with the actual pipe	- Adjust the flow rate span according to the actual flow rate value. Or perform the target calibration. - If you do not know the actual flow rate, set the correct diameter and thickness of the pipe.
	The origin adjustment has not been correctly performed.	Perform the origin adjustment again when the pipe is filled with fluid and the fluid is still.
	The characteristic of the fluid largely differs from that of water.	- Adjust the flow rate span according to the actual flow rate value. Or perform the target calibration. - If you do not know the actual flow rate, enter the velocity of ultrasonic waves and kinematic viscosity.
	The flow velocity distribution is not uniform due to laminar flow or drift etc.	- Move the sensor to a different location. - Adjust the flow rate span according to the actual flow rate value. Or perform the target calibration.
- Instantaneous flow rate is displayed even when there is no fluid flow - Shot amount or integrated flow amount counts up even when there is no fluid flow	The origin adjustment has not been correctly performed.	Perform the origin adjustment again when the pipe is filled with fluid and the fluid is still.
	The pipe is not filled with fluid.	- Install the sensor so that the pipe is filled with fluid. - Install the sensor so that the display is perpendicular to the ground, not parallel.
	The zero cut flow rate is set to a small value	- Set the response time to a longer value. - Increase the zero cut flow rate. - Set the display averaging to a longer value.
The display turns on and off.	- The power is not turned ON. - The cable is damaged.	- Check the power capacity. - Check the wiring for crossed wires or loose connections. - Check the sensor cable for breakage.
The target calibration cannot be executed and "Error" is displayed.	An error occurs during the target calibration in the following cases. Resolve the cause of the error then perform the calibration again. - When any of the following errors occur during sampling: Head Error/---/Bubble Alert*/rEv (*only for the bubble detection mode) - When the sampling result is any of the following: 0, a minus figure or over the limit of the display - When the entered value is outside the input possible range for the span adjustment value or zero cut flow rate value [Pro Settings] is selected in the Correcting the flow rate value (page 8)	

10-2 Output Status during Errors

Display	Control output*	Analog output	Recorded data	Controller output indicator/sensor head status indicator
Head Error	OFF	When set to 4-20mA: 3.5mA When set to 0-20mA: 0mA	Recorded as zero flow rate	Blinks red
Over Current	OFF	Normal operation	Normal operation	Blinks red
EEPROM Error	Normal operation	Normal operation	Does not work	Blinks red
rEv	OFF	When set to 4-20mA: 3.5mA When set to 0-20mA: 0mA	Recorded as zero flow rate	Normal operation
----	Operates as if the flow rate is zero.	When set to 4-20mA: 3.5mA When set to 0-20mA: 0mA	Recorded as zero flow rate	Operates as if the flow rate is zero.

* In the error output mode, an output is generated for errors other than Over Current (when the output logic is N.O.).

11 Specifications

11-1 Sensor head specifications

Sensor head model			FD-XS1			FD-XS8			FD-XS20					
Supported pipe materials			Metal pipe, Plastic pipe (Soft/Hard) ^{*1}											
Supported fluids			Liquids (water, oil, adhesive, grease, chemical solution etc.) ^{*1}											
Supported fluid temperature (Pipe surface temperature)			0°C (no freeze on the pipe surface) to 100°C											
Supported diameter	Plastic pipe attachment	Clamp set model	FD-XC1R1		FD-XC1R2	FD-XC8R1	FD-XC8R2	FD-XC8R3	FD-XC20R1	FD-XC20R2	FD-XC20R3	FD-XC20R4		
		Outer diameter of pipe	φ3	1/8" (3.18 mm)	φ4	φ6	1/4" (6.35mm)	φ8	3/8" (9.53mm)	φ10	φ12	1/2"(12.7mm)		
		Attachable range	φ2.7 to 3.7		φ3.5 to 4.5	φ5.5 to 6.5	φ5.9 to 6.9	φ7.5 to 8.5	φ9.0 to 10.0	φ9.5 to 10.5	φ11.5 to 12.5	φ12.2 to 13.2		
	Metal pipe attachment	Clamp set model	FD-XC1M			FD-XC8M			FD-XC20M1			FD-XC20M2		
		Outer diameter of pipe	φ3	1/8" (3.18 mm)	φ4	φ6	1/4" (6.35mm)	φ8	3/8" (9.53mm)	φ10	φ10.5	φ12	1/2" (12.7mm)	φ13.8
		A designation	-	-	-	-	-	-	-	-	6A	-	-	8A
Attachable range		φ2.8 to 5.5			φ5.5 to 8.3			φ8.3 to 10.8			φ10.8 to 14			
Rated flow rate			0 to 1000 mL/min			0 to 3000 mL/min		0 to 8000 mL/min		0 to 15.00 L/min		0 to 20.00 L/min		
Zero cut flow rate ^{*2} (variable, default)			20 mL/min			40 mL/min				0.10 L/min				
Display resolution (Displayed on controller)		Instantaneous flow rate	0.1/1/10 mL/min						0.001/0.01/0.1 L/min					
		Shot amount	0.001/0.01/0.1/1 mL						0.001/0.01/0.1 L					
Repeat- ability ^{*3}	Plastic pipe attachment	Response time: 50ms ^{*4}	F.S.		±0.6%		±0.1%							
		Instantaneous flow rate	±6 mL/min		±3 mL/min		±8 mL/min		±15 mL/min		±20 mL/min			
		Response time: 500ms	Instantaneous flow rate	±1.9 mL/min		±1.0 mL/min		±2.6 mL/min		±4.7 mL/min		±6.3 mL/min		
	Metal pipe attachment	Response time: 50ms ^{*4}	F.S.		±1%		±0.3%		±0.15%					
		Instantaneous flow rate	±10 mL/min		±9 mL/min		±12 mL/min		±23 mL/min		±30 mL/min			
		Response time: 500ms	Instantaneous flow rate	±3.2 mL/min		±2.9 mL/min		±3.8 mL/min		±7.2 mL/min		±9.5 mL/min		
Hysteresis			Variable											
Integrated unit display (displayed on controller)			0.1/1/10/100/1000/10000 mL						0.01/0.1/1/10/100 L					
Display method			Status indicator											
Environmental resistance	Enclosure rating		IP65/IP67 (IEC60529), IP68G (JIS C0920) ^{*5}											
	Ambient temperature		0 to 60°C (No freezing)			-10 to 60°C (No freezing)								
	Ambient humidity		35% to 85% RH (No condensation)											
	Vibration resistance		10 to 55Hz, double amplitude 1.5mm, 2 hours each for X,Y,Z direction											
	Shock resistance		50G 11ms 3 times each for X,Y,Z direction											
Material	Sensor head		Head body: PPS/PPSU, in-cable amplifier: PPS, cable: PVC, controller connector: PPS/PBT/POM											
	Clamp set	For plastic pipe	Body, fixing screw: PPS, detection surface: special rubber, pipe support rubber: FKM, sensor head fixing screw: SUSXM7											
		For metal pipe	Metal: SUS304/SUSXM7, detection surface: special rubber, clamp support rubber: FKM, sensor head fixing screw: SUSXM7											

*1 Liquid must allow for the passage of an ultrasonic pulse, as well as not contain large air pockets or excessive bubbles. Measurement may become unstable depending on the type of the pipe.
*2 The zero cut flow rate can be changed in the settings. When using the unit with a low flow rate range, perform an origin adjustment when the fluid is not moving if you change the zero cut flow rate.
*3 This specification is valid when the flow velocity distribution is stable. This value does not take into account the effects of pulsation or fluctuations in flow velocity distribution due to facility factors. Convert the F.S. (full scale) listed in the table according to the rated flow range.
*4 The longer the response time is set, the more repeatability is improved. As a guideline, use √ (50ms/response time) times.
*5 The connector part of the sensor head cable is IP65 / IP67.

Shot amount repeatability (Typical values)

Sensor head model			FD-XS1			FD-XS8			FD-XS20					
Plastic pipe attachment	Clamp set model		FD-XC1R1		FD-XC1R2	FD-XC8R1	FD-XC8R2	FD-XC8R3	FD-XC20R1	FD-XC20R2		FD-XC20R3	FD-XC20R4	
	Diameter of pipe		φ3	1/8" (3.18 mm)	φ4	φ6	1/4" (6.35mm)	φ8	3/8" (9.53mm)	φ10		φ12	1/2"(12.7mm)	
	Shot time	50ms	±0.005mL			±0.003mL		±0.004mL		±0.006mL		±0.008mL		
		1s	±0.015mL			±0.008mL		±0.012mL		±0.019mL		±0.023mL		
		10s	±0.044mL			±0.024mL		±0.036mL		±0.057mL		±0.071mL		
Metal pipe attachment	Clamp set model		FD-XC1M			FD-XC8M			FD-XC20M1			FD-XC20M2		
	Diameter of pipe		φ3	1/8" (3.18 mm)	φ4	φ6	1/4" (6.35mm)	φ8	3/8" (9.53mm)	φ10	6A (10.5mm)	φ12	1/2" (12.7mm)	8A (13.8mm)
	Shot time	50ms	±0.007mL			±0.008mL			±0.009mL			±0.012mL		
		1s	±0.021mL			±0.025mL			±0.027mL			±0.036mL		
		10s	±0.063mL			±0.075mL			±0.083mL			±0.112mL		

*1 Repeatability of the shot amount is the typical value for water, response time of 50ms, no zero cut setting and after origin adjustment.
*2 Variations due to facility (such as pulsation, valve control, liquid pool, change in flow velocity distribution) are not taken into account in this value.

11-2 Controller specification

Model		FD-XA1		FD-XA2		FD-XA5	
Type		DIN rail type, main unit		DIN rail type, expansion unit		Panel mounting type, main unit	
Display method		Output indicator, 4-digit 7 segment display, OLED, Stability level display					
Display refresh frequency		Instantaneous flow: approx. 5 times/second, Discharge amount/Accumulated flow approx. 30 times/second					
Response time		50ms/ 100ms/ 500ms/ 1s/ 2.5s/ 5s/ 10s/ 30s/ 60s (selectable, default: 500ms)					
Integration data storage interval		Written to the memory every 10 seconds					
Memory back up*1		EEPROM (data storage period: more than 10 years, number of data rewritable times: 1 million times or more)					
Detection mode (selectable)	ch.1	Instantaneous flow rate mode/Area mode/Pulse output (+) mode/Integrated flow mode/Shot mode					
	ch.2	Instantaneous flow rate mode/Area mode/Pulse output (-) mode/Shot mode/Error output mode/Bubble alert mode/Error + bubble alert mode					
Input/output	Output ch.1/2	NPN/PNP setting switch Open collector output: 30V or lower, main unit: 50mA or lower/ch. ^{*2} /expansion unit: 20mA or lower/ch., residual voltage: 2V or lower					
	Analog output	4-20mA/0-20mA (selectable) load resistance: 500ohm or lower		-		4-20mA/0-20mA (selectable) load resistance: 500ohm or lower	
	External input 1/2	Flow rate zero input/shot sampling input/integrated flow reset input/zero shift input (selectable) Short circuit current: NPN 1mA or lower/PNP 2mA or lower, input time: 20ms or longer					
Network support		IO-Link ^{*3}		Supports NU series		IO-Link ^{*3}	
Power source	Power supply voltage	20 to 30 VDC including 10% ripple (P-P), Class 2					
	Current consumption	195mA or lower (including the sensor head, excluding the load current)		185mA or lower (including the sensor head, excluding the load current)		195mA or lower (including the sensor head, excluding the load current)	
Protection circuit		Power supply reverse connection protection, power surge protection, output short circuit protection, output surge protection					
Addition of expansion units		Up to 7 ^{*4} per main unit				-	
Environmental resistance	Ambient temperature	-10 to +50°C (No freezing)					
	Ambient humidity	35% to 85% RH (No condensation)					
	Vibration resistance	10 - 55Hz, double amplitude 1.5mm, 2 hours each for X,Y,Z direction					
	Shock resistance	100m/s ² (approx. 10G) 16ms pulse, 1000 times each for X,Y,Z direction					
Material		Main body case/front sheet: PC Key top: POM Cable: PVC					

^{*1} Internal data of full time recording can be read by USB (Ver.2.0) communication.

^{*2} 20mA or lower/ch when adding expansion units.

^{*3} IO-Link: Specification v1.1/COM2(38.4kbps) is supported. If the end of the cable needs to be an M12 connector when supporting IO-Link, connect an M12 conversion connector (OP-88296) to the cable.

^{*4} Refer to page 2 of the Instruction Manual for the number of connected units to N-bus devices.

11-3 Default Settings/Values List

Item	FD-XS1	FD-XS8	FD-XS20
a.NPN/PNP Selection	NPN		
b.Flow Direction Selection	Toward the LED from the cable		
c.Pipe Material Selection	Metal		
d.Nominal Outer Diameter of Pipe Selection	φ4	φ6	φ10
e.Flow Unit Selection	mL(L)/min		
1.ch.1 detection mode	Standard		
2.ch.1 output logic	N.O.		
3.ch.2 detection mode	Standard		
4.ch.2 output logic	N.O.		
5.Analog output current	4-20 mA		
6.Analog output lower limit	0	0	0.00
7.Analog output upper limit	1000	8000	20.00
8.Input 1 function selection	Off		
9.Input 2 function selection	Off		
10.Response time	500 ms		
11.Integrated flow unit	1 mL	1 mL	0.01 L
A1.Display resolution (instantaneous)	1 mL/min	1 mL/min	0.01 L/min
A2.Display resolution (shot amount)	0.01 mL	0.01 mL	0.001 L
A3.Display averaging	1.0 s		
A4.Hysteresis	10	20	0.05
A5.Zero cut flow rate	20	40	0.10
A6.Head LED illumination mode	Green		
A7.Screen brightness	30%		
A8.Password	Off		
A9.Flow direction selection	Toward the LED from the cable		
A10.Nominal outer diameter of pipe selection	φ4	φ6	φ10
A11.Flow rate tuning	Off		
A12.Pipe outer diameter input	4.00 mm	6.00 mm	10.00 mm
A13.Pipe thickness input	1.00 mm	1.00 mm	1.00 mm
A14.Liquid type selection	Water		
A15.Ultrasonic speed input	1497 m/s		
A16.Kinematic viscosity input	1.0 cSt		
A17.Span adjustment	1.000		
B1.Calibration target value	±25%		
B2.Integrated flow rate subtraction	Off		
B3.Shot rate subtraction	Off		
B4.Bubble cancellation setting	Default		
B5.Bubble cancellation sensitivity	Mid		
B6.Hold duration	5 s		
B7.Bubble detection setting	Default		
B8.Bubble detection sensitivity	Mid		
B9.One-shot output time	1.0 s		
F1.Data transmission	No		
F2.Communication baud rate	921.6 kbps		
F3.Transmission data selection	Block		
F4.Data amount selection	2000		
F5.Recording frequency	5 min		
F6.Stop recording	Off		
Instantaneous flow rate threshold P1/P1-L	100	800	2.00
Instantaneous flow rate threshold P1-H	400	3200	8.00
Instantaneous flow rate threshold P2/P2-L	200	1600	4.00
Instantaneous flow rate threshold P2-H	300	2400	6.00
Shot threshold S1-L	1.00	3.00	0.015
Shot threshold S1-H	6.00	18.00	0.090
Shot threshold S2-L	2.00	6.00	0.030
Shot threshold S2-H	4.00	12.00	0.060
Threshold of integrated flow	200	600	300

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