

Radar Type Level Sensor
FR Series

Short-range type with built-in display
(FR-S01)

Instruction Manual

Details about the FR Series functions and how to use the unit can be found in the "FR Series User's Manual." A copy of the "FR Series User's Manual" can be downloaded off of the KEYENCE website. Alternatively, contact a local KEYENCE representative. KEYENCE website: <http://www.keyence.com>

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 used at any time.

Symbols

The following symbols alert you to important messages. Be sure to read these messages carefully.

	Indicates a hazardous situation which, if not avoided, will result in death or serious injury.
	Indicates a hazardous situation which, if not avoided, could result in death or serious injury.
	Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
	Indicates a situation which, if not avoided, could result in product damage as well as property damage.
	Indicates cautions and limitations that must be followed during operation.
	Indicates additional information on proper operation.
	Indicates tips for better understanding or useful information.

Safety Precautions

General precautions

	<ul style="list-style-type: none">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 use this product in an application that may cause death, serious injury, or serious property damage due to a failure with this product occurring, such as in nuclear power plants; on aircraft, trains, ships, or vehicles; used within medical equipment, playground equipment, roller coasters, and other rides.
	<ul style="list-style-type: none">Do not use the FR-SH01(C) for applications such as beverages, food, and medical services. Also, if using the FR-LP(H)20(L) for applications such as beverages, food, and medical services, be sure to use a ferrule mounting bracket (OP-88888).If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.You must perform a sufficient risk assessment for the machine where this product is to be installed prior to installing this product. Provide appropriate protective fail-safe measures on the machine independent from this product in case a failure with this product should occur.
	<ul style="list-style-type: none">Before starting operation and during operation, verify the functions and performance of the product.In case any failure occurs with the product, take sufficient safety measures to prevent further damage.
	<ul style="list-style-type: none">If the product is used in combination with other equipment, the functions and performance may not meet expectations depending on the operating condition, environment, and other conditions. Consider these points before using this product.If this product is used for an acid or alkaline medium, or for an application within sanitary environments and electroplating, check the resistance of the sensor materials to the target medium or application beforehand.

Precautions on media

	Measured values may exceed the upper limit if conductive components in the target medium adhere to the bottom of the main unit. In this case, clean the bottom of the main unit to remove the adhered substances.
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Precautions on handling

	<ul style="list-style-type: none">When detecting a high-temperature liquid, the temperatures of the metal components of the sensor will also rise, which may cause burns. Do not touch these metal components during operation.Do not touch the threads of the main unit because it is sharp.
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Precautions on installation

	<p>Do not install the sensor in the following locations, as this may result in an accident:</p> <ul style="list-style-type: none">A location where the main unit is subject to vibrations or impact greater than its environmental resistanceA location whose ambient temperature does not fall within the ambient operating temperature rangeA location where the humidity surrounding the main unit exceeds 85%RH (no condensation)A location subject to sudden changes in temperatureA location with any volatile combustibles, solvents, or corrosive gasesA location with a strong magnetic or electric field
	<p>During installation, take the following into account to improve the noise immunity. Otherwise, a malfunction may occur.</p> <ul style="list-style-type: none">Do not use a power cable whose length exceeds 30 m (20 m if using IO-Link).Mount the sensor as far away as possible from any power lines.Mount the sensor as far away as possible from any equipment generating a high electric or magnetic field (such as solenoids and choppers).Wire input/output signal lines separately from power and high-tension lines. <p>Power supply</p> <ul style="list-style-type: none">Noise superimposed on the power supply may result in malfunction. Be sure to use a stabilized DC power supply with an isolating transformer.When using a commercially available switching regulator, be sure to ground the frame ground terminal.Failing to abide by the recommended installation conditions in this manual may lead to unstable detection.

Precautions on Regulations and Standards

CE and UKCA marking

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

RE Directive (CE) and Radio Equipment Regulations (UKCA)

- Operating frequency: 58 to 63 GHz
- Maximum radio output:
 - FR-S(H)01(C): -12.81 dBm (0.05 mW)
 - FR-LM(H)20/LP(H)20/LS20: -5.89 dBm (0.26 mW)
 - FR-LM(H)20L/LP(H)20L/LS20L: -17.36 dBm (0.02 mW)

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

CSA certificate

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

- Overvoltage category I
- Pollution degree 3 (FR-S(H)01(C)/SA1/SA2/SA1C/SA0/LS20(L))
- Pollution degree 4 (FR-LM(H)20(L)/LP(H)20(L))
- Use this product at an altitude of 5000 m or less.
- Use a CSA/UL certified power supply that provides Class 2 output as defined in the CEC (Canadian Electrical Code) and NEC (National Electrical Code).

Precautions on radio communication

- The FR Series uses the 60 GHz band.
- Radio frequency interference slowing or even preventing measurement may occur if this product is used in the vicinity of equipment that uses the same frequency band such as wireless LAN equipment, microwaves, factory-use heaters, and high-frequency medical equipment.
- KEYENCE declares that the FR-S(H)01(C)/LS20(L)/LM(H)20(L)/LP(H)20(L) complies with Radio Equipment Directive 2014/53/EU.
- The entirety of this declaration of conformity with this EU directive is available at the following Internet address.
[www.keyence.com/cedoc]

- 사용자 안내문
이 기기는 업무용 환경에서 사용할 목적으로 적합성평가를 받은 기기로서 가정용 환경에서 사용하는 경우 전파간섭의 우려가 있습니다.
본 기기는 통신 이용 상태의 경우 인체(머리, 몸통)와 20cm 초과하는 거리에서 사용되어야 합니다.

Precautions on radio communication (FR-S(H)01(C)/LS20/LM(H)20L/LP(H)20L)

- This device complies with part 15 of the FCC Rules.
- Operation is subject to the following two conditions:
 - (1) This device may not cause harmful interference, and
 - (2) this device must accept any interference received, including interference that may cause undesired operation.
- FCC CAUTION Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment.
- This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.

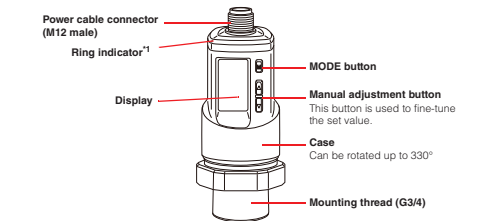
- Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.
- This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment and meets the FCC radio frequency (RF) Exposure Guidelines.
- This equipment should be installed and operated keeping the radiator at least 20cm or more away from person's body.
- This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:
 - 1. This device may not cause interference.
 - 2. This device must accept any interference, including interference that may cause undesired operation of the device.
- L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:
 - 1. L'appareil ne doit pas produire de brouillage;
 - 2. L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.
- This equipment complies with ISSED radiation exposure limits set forth for an uncontrolled environment and meets RSS-102 of the ISSED radio frequency (RF) Exposure rules.
- This equipment should be installed and operated keeping the radiator at least 20cm or more away from person's body.
- Cet équipement est conforme aux limites d'exposition aux rayonnements énoncées pour un environnement non contrôlé et respecte les règles d'exposition aux fréquences radioélectriques (RF) CNR-102 de l'ISDE.
- Cet équipement doit être installé et utilisé en gardant une distance de 20 cm ou plus entre le radiateur et le corps humain.
- 取得實驗證明之低功率射頻器材，非經核准，公司、商號或使用者均不得擅自變更頻率、加大功率或變更原設計之特性及功能。低功率射頻器材之使用不得影響飛航安全及干擾合法通信；經發現有干擾現象時，應立即停用，並改善至無干擾時方得繼續使用。前述合法通信，指依電信管理法規定作業之無線電通信。低功率射頻器材須忍受合法通信或工業、科學及醫療用電波輻射性電機設備之干擾。

Packaged Items

- Main unit
- Instruction Manual

System Configuration Example and Name of Each Component

Short-range type with built-in display



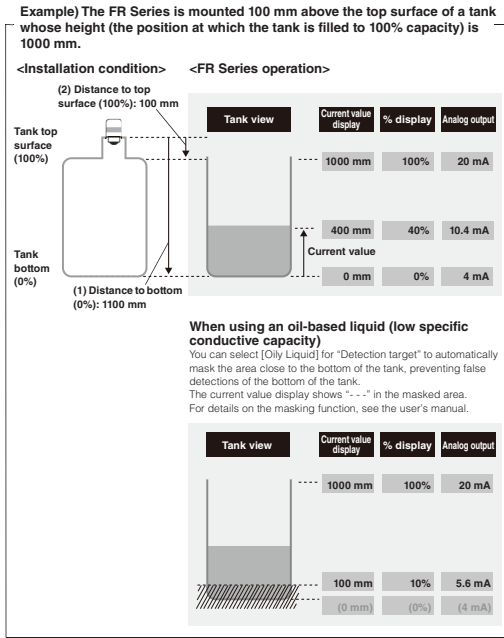
*1 Lights in red, yellow, or green depending on the "Indicator pattern" setting.

Product Overview

The FR Series allows you to specify the following values.

- The distance from the reference surface of the sensor to the bottom of the tank (0%)
- The distance from the reference surface of the sensor to the top surface of the tank (100%)

With these values specified, the sensor displays the level of the liquid/powder from the bottom of the tank.



Installation and Mounting

Mounting the sensor

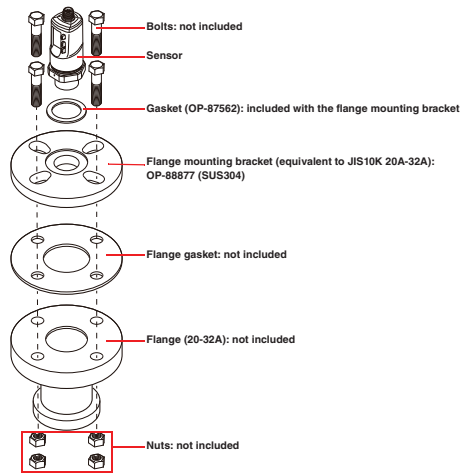
■ Mounting on the flange nozzle

- 1 Fit a gasket (included with the flange mounting bracket)¹ on the flange mounting bracket, and then mount the sensor on the flange mounting bracket.

Recommended tightening torque: 30 N·m

- 2 Insert a flange gasket¹ between the flange mounting bracket and the flange nozzle, and then use bolts and nuts to secure the parts.

¹ A gasket is not required if an airtight seal is not required.

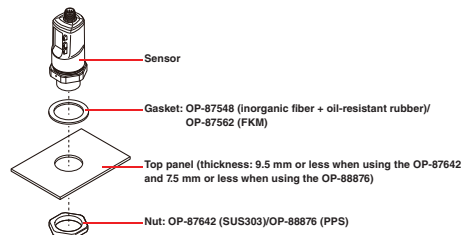


■ Mounting directly on a top panel (mounting with a nut)

- 1 Drill a hole with a diameter of 27 mm in the top panel.
- 2 Fit a gasket¹ on the threads of the sensor, and then insert the threads in the hole in the top panel.
- 3 Attach a nut from the bottom of the top panel.

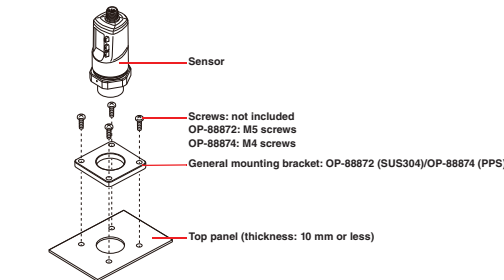
Recommended tightening torque: 30 N·m

¹ A gasket is not required if an airtight seal is not required.



■ Mounting directly on a top panel (using a general mounting bracket, not a nut)

- 1 Insert the threads of the sensor into a general mounting bracket. Recommended tightening torque: 30 N·m
- 2 Drill a hole with a diameter of 40 mm in the top panel, and then use screws to secure the general mounting bracket on this panel.



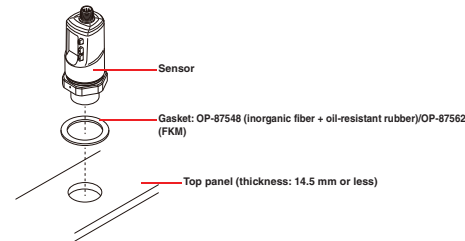
Reference It is not necessary to attach nuts from the bottom.

■ Mounting directly on a top panel (screwing in the device)

- 1 Drill a G3/4 screw hole in the top panel.
- 2 Fit a gasket¹ on the threads of the sensor, and then insert this mounting screw in the hole in the top panel.

Recommended tightening torque: 30 N·m

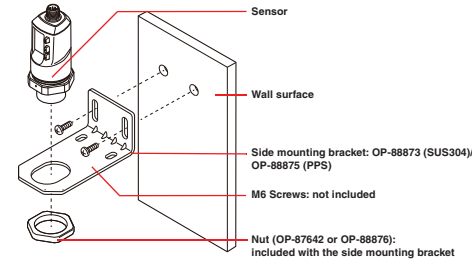
¹ A gasket is not required if an airtight seal is not required.



■ Mounting on an inner wall

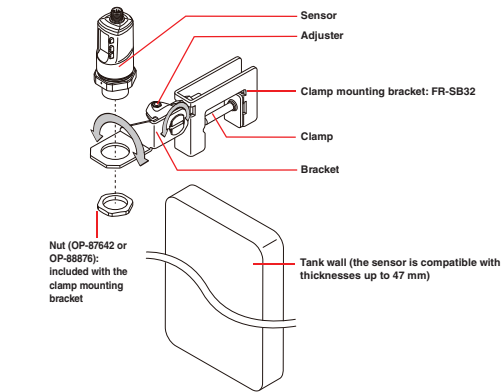
- 1 Mount a side mounting bracket on a wall with M6 screws.
- 2 Insert the sensor into the bracket, and then attach a nut from the bottom of the bracket.

Recommended tightening torque: 30 N·m



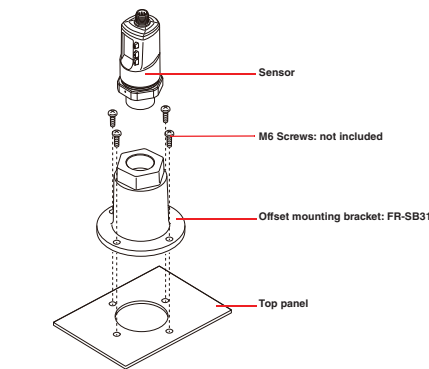
■ Clamping to the tank wall

- 1 Attach the clamp of the mounting bracket to the tank wall, and then turn the screw to tighten the clamp.
- 2 Insert the sensor into the clamp mounting bracket, and then attach a nut from the bottom of the bracket. Recommended tightening torque: 30 N·m
- 3 Loosen the socket head cap screw (width between two surfaces: 4 mm) on the adjuster to rotate the bracket. Tighten this screw again after adjusting the bracket to the desired angle. Recommended tightening torque: 3.5 N·m



■ Offset mounting

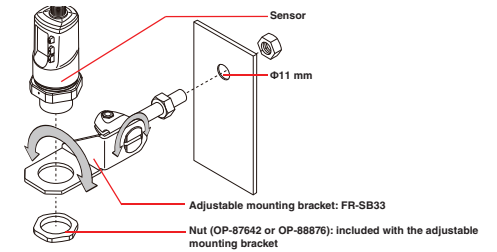
- 1 Drill a hole with a diameter of 50 mm and four M6 screw holes in the top panel.
- 2 Mount an offset mounting bracket to the top panel of the tank with M6 screws.
- 3 Mount the sensor on the offset mounting bracket. Recommended tightening torque: 30 N·m



NOTICE If the liquid surface or bubbles reach the undetectable area, you can stabilize detection by mounting the offset mounting bracket at further distance from the liquid surface or bubbles.

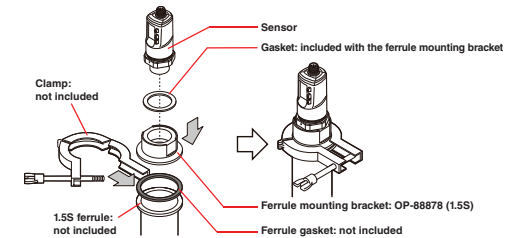
■ Adjustable mounting

- 1 Mount the threaded bolt of an adjustable mounting bracket on the inner wall of a tank or similar object. (Recommended tightening torque: 24.5 N·m)
- 2 Insert the sensor into the hole of the adjustable mounting bracket, and then attach a nut from the bottom of the bracket. Recommended tightening torque: 30 N·m
- 3 Loosen the socket head cap screw (width between two surfaces: 4 mm) on the adjuster to rotate the bracket. Tighten this screw again after adjusting the bracket to the desired angle. Recommended tightening torque: 3.5 N·m



■ Mounting on a ferrule

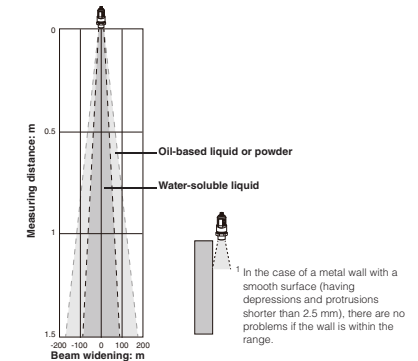
- 1 Mount a gasket on the ferrule mounting bracket, and then mount this bracket on the sensor.
- 2 Mount the ferrule gasket on the ferrule.
- 3 Use a clamp to mount the sensor on the ferrule.



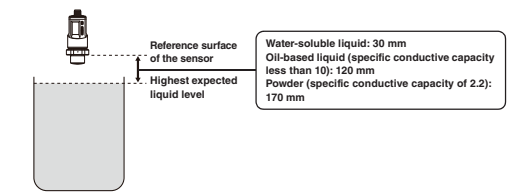
Recommended installation conditions

The FR Series beam widens as follows.

Ensure there are no metal obstacles in the following range.



Detection may be unstable at close distances.
It is recommended to install the sensor so that its reference surface is, at a minimum, at the following distances from the highest expected liquid level.



Adjusting the orientation of an installed sensor

The case can be rotated up to approximately 330°. After securing the sensor to a mounting bracket or something similar, rotate the case while holding the hexagon part in place with a wrench to orient the display as desired.

Wiring

Pin layout

Power cable connector pin layout

Pin #	Color	Description
1	White	Analogue output
2	Brown	Power supply (24 VDC)
3	Green	OUT3
4	Yellow	OUT4
5	Gray	OUT1
6	Pink	OUT2*
7	Blue	0 V
8	Red	OUT5/IN

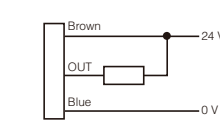
* IO-Link-compatible wire when connecting an IO-Link device

Independently insulate any unused input/output wires.

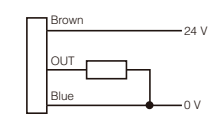


(1) Control output wiring

NPN

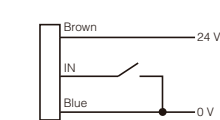


PNP

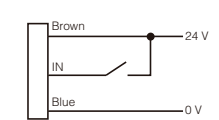


(2) External input wiring

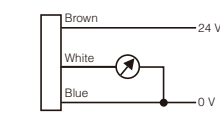
NPN



PNP



(3) Analog output wiring



* It is possible to switch between 4-20 mA and 0-20 mA using settings.

Connecting the Power Cable

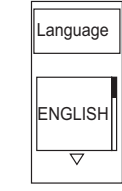
1 Plug the power cable into the power cable connector.

NOTICE When connecting the connector, plug it in straight and fix it firmly. If the tightening is not sufficient, the connector may loosen, which may lead to contact failures.

Initial Setting at First Startup

When the sensor is turned on for the first time, configure the following initial settings.

- Select parameters with the Δ and ∇ keys and use the MODE key to confirm entries.
- After you confirm all the parameters on one screen, you will move to the next one.
- To return to the previous screen, hold down the MODE key and press the Δ key.



Underlined items are initial values

Language	<u>ENGLISH</u> , 日本語, 中文, DEUTSCH
PNP/NPN	<u>PNP</u> , NPN
Control outputs	<u>0</u> , 1, 2, 3, 4, 5
External input	<u>OFF</u> , ON
Detection target	<u>Water-soluble liquid</u> , Oily Liquid, Powder
Distance unit	<u>mm</u> , m
Bottom distance	<u>0</u> to 2000mm ^{*1}
Top Distance	<u>0</u> to 2000mm ^{*1}
Set value 1 ^{*2}	<u>0</u> to 99999
Output 1 logic ^{*2}	<u>N.O.</u> , N.C.
Indicator order ^{*3}	<u>Order 1</u> , Order 2, Order 3, Only green, Always Off

^{*1} The unit and decimal point position vary depending on the "Distance unit" setting.
^{*2} Numbers 1 to 5 are displayed depending on the value selected with "Number of control outputs." Nothing is displayed if [0] is selected with "Number of control outputs."
^{*3} The selectable number of patterns varies depending on the "Number of control outputs" setting.

Number of control outputs

At most, there are five outputs, one external input, and one analog output.

- Set the number of control outputs to use.
- The set number of control outputs are assigned in order from OUT1. You can only use up to four control outputs when you select [ON] for "External input."
- Other functions can be assigned to outputs to which control outputs are not assigned.
- For details on these functions, see the user's manual.
- Each control output can also be changed to area mode.
- For details on area mode, see the user's manual.

Pin #	Color	Name	Control output	Auxiliary output			External input Reset period change	Analog output	IO-Link
				Error	Stability alarm	Period change			
5	Gray	OUT1	✓	✓	✓	✓	-	-	-
6	Pink	OUT2	✓	✓	✓	✓	-	-	*
3	Green	OUT3	✓	✓	✓	✓	-	-	-
4	Yellow	OUT4	✓	✓	✓	✓	-	-	-
8	Red	OUT5/IN	✓	✓	✓	✓	✓	-	-
1	White	Analog output	-	-	-	-	-	✓	-

* During IO-Link communication, this cannot be used as output, but the OUT2 function can be used.

Detection target

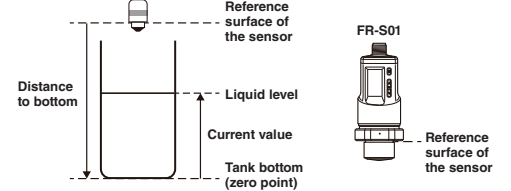
Select [Water-soluble liquid] if the specific conductive capacity of the measurement target is 10 or higher, [Oil-based liquid] if the specific conductive capacity of the target is less than 10, and [Powder] if the target is a powder. If you select [Oil-based liquid], the area from the base to 10% of the height of the tank on the side far from the sensor is masked.

For details, see the user's manual.

Point Selecting an incorrect detection target may prevent accurate detection of the liquid surface.

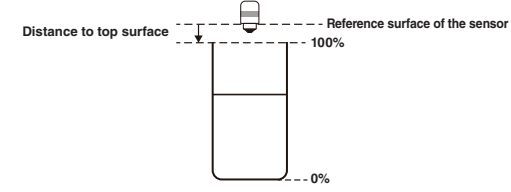
Distance to bottom

Enter the distance from the reference surface of the sensor to the bottom of the tank. For the position of the reference surface of the sensor when using a mounting bracket, see the dimensions provided in, for example, the catalog. See the dimensions for the position of the reference surface of the sensor when using a mounting bracket. The position indicated as the tank bottom is 0% in the % display.



Distance to top surface

Enter the distance from the reference surface of the sensor to the top surface of the tank. This position is 100% in the % display.

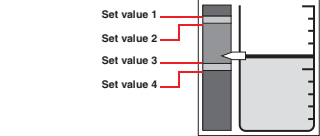


Output logic 1

N.O.: Control output turns on when the current value exceeds one of the set values.
N.C.: Control output turns on when the current value drops below one of the set values.

Indicator pattern

You can select the lighting order of the ring indicator according to the liquid surface position. The indicator color is also linked to the color bar on the current value screen.

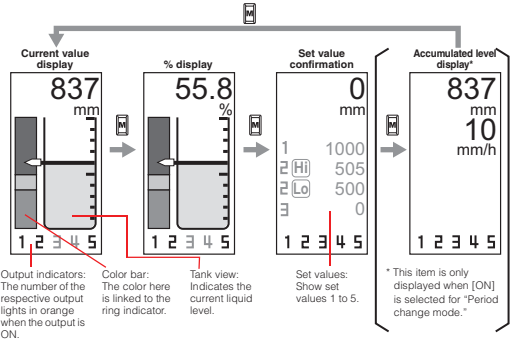


The number of selectable indicator orders varies depending on the number of control outputs. Select the indicator pattern from those shown below. To use a different pattern, select Custom. For details on how to set custom order, see the user's manual.

Number of control outputs	Order 1	Order 2	Order 3	Only green	Always Off
0				Green	
1	Red Green	Green Red		Green Green	
2	Red Yellow Green	Green Yellow Red	Red Green Red	Green Green Green	
3	Red Yellow Green Red	Red Green Yellow Red	Red Green Green Green	Green Green Green Green	
4	Red Yellow Green Green Yellow Red	Red Green Green Green Red		Green Green Green Green Green	
5	Red Yellow Green Green Green Yellow Red	Red Green Green Green Green Red		Green Green Green Green Green Green	

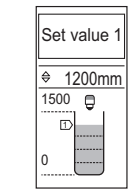
Basic Operation

Current value screen



Changing set values

Hold down the MODE key on the current value display to enter the menu, and then select Change set value. Use the Δ and ∇ keys to change the set value, and then confirm the change with the MODE key.



Key lock

This function prevents operation mistakes by locking/disabling key operations to prevent the settings from being easily changed. To require a password when canceling the key lock, set "Key lock method" to "With password." Enabling/disabling the key lock: Hold down the MODE key and the ∇ key for 3 seconds or more. When "Key lock method" is set to "With password," the password is required when unlocking the keys.

Reference If the password entered is incorrect, an error will occur, and the normal screen will appear with the key lock still enabled.

Initializing settings

On the current value screen, hold down the MODE key and press the Δ key five times to initialize all settings.

Maintenance

Clean deposits and foreign substances on the mounting bracket and the bottom of the sensor as necessary.

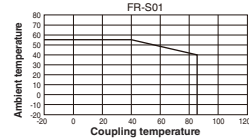
Specifications		
Item		FR-S01
Measurement range ^{*1}		to 1500 mm to 4.9 ft
Displayable range ^{*1}		to 2000 mm to 6.6 ft
Specific conductive capacity of target media ^{*2}		2 or more
Resolution		1 mm
Accuracy ^{*3}		0 to 0.3 mm: ±5 mm 0.3 to 1.5 mm: ±1 mm
Control output response time		0.4 s, 1.5 s, 4 s (default), 10 s
Tank pressure		-0.1 to 1 MPa
Material	Inside the tank	Lens: PTFE Internal packing: FKM Entering part: SUS304
	Case	PPS PBT PAR
Connection port		G3/4 (20A)
Output	Number of control outputs	Max. 5
	Control output/alarm output	NPN/PNP open collector (switchable), 30 VDC max., 50 mA max. for each output, residual voltage: 1.4 V max. (50 mA max.), N.O./N.C. switchable, IO2 also used for IO-Link, IO5 also used for external input
	Analog output	0 to 20 mA/4 to 20 mA, maximum load resistance: 260 Ω (Response time: 0.2 s after comparator output determined [90% response])
External input		Short circuit current: max. 1.5 mA, input time: min. 500 ms
Network compatibility		IO-Link v1.1/COM2
Analog output accuracy	Resolution	1 mm
	Zero accuracy	±0.1 mA (zero = 4 mA)
	F.S. accuracy	±0.2 mA (F.S. = 20 mA)
Environmental resistance	Ambient temperature	-20 to +55°C (no freezing) ^{*4, *5}
	Ambient humidity	Up to 85%RH (no condensation)
	Operating coupling temperature	-20 to +85°C (no freezing) ^{*4, *5}
	Vibration resistance	10 to 500 Hz; Power spectral density: 0.816 G ² /Hz; X, Y and Z directions
	Shock resistance	100 m/s ² (approx. 10 G), 16 ms pulses, 1000 times each for X, Y and Z axes
Enclosure rating		IP67
Protection circuit		Protection against reverse power connection, output overcurrent, output surge, and reverse output connection
Power voltage		24 VDC+25%/-20% including ripple, Class 2/LPS
Current consumption		50 mA max. (at 20 V)/ 40 mA max. (at 30 V) (excluding load)
Corresponding cable/connector		8-pin M12 connector
UI	Display	LCD, ring indicator
	Key switches	3 (up, down, and MODE)

^{*1} Value guaranteed with water and the recommended mounting method. With water and the recommended mounting method, measurement is possible right up to the lens surface. An undetectable area on the near side occurs due to the relationship between the environment and the measurement medium. Additionally, the maximum measuring distance decreases.

^{*2} The target shape or the environment may make measurement impossible.

^{*3} This value is guaranteed by KEYENCE inspection facilities. Errors may occur due to your environment.

^{*4} The operating temperature range for each model is as follows.



On the FR-S01, selecting [Turns off when no op.] for “Screen brightness” can alleviate the ambient temperature regulation by 10°C.

^{*5} When performing SIP, turn the power supply off, and then perform this operation for 1 hour or less with an ambient temperature of 40°C or less and an internal system temperature of 130°C. Also, be sure to attach a ferrule mounting bracket and an internal gasket, which are optional KEYENCE products.

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