

INSTRUCTION MANUAL

Miniature flow rate switch RAPIFLOW®

FSM-X Series

▪ Analog output type

- Please read this instruction manual carefully before using this product, particularly the section describing safety.
- Retain this instruction manual with the product for further consultation whenever necessary.
- On use, evaluate it enough and consider quality and performance and safety.
- This product is for vacuum adsorption verification.



Safety precautions

Always read before starting use.

When designing and manufacturing a device using CKD products, the manufacturer is obligated to check that device safety mechanical mechanism, pneumatic control circuit, or water control circuit and the system operated by electrical control that controls the devices is secured.

It is important to select, use, handle, and maintain the product appropriately to ensure that the CKD product is used safely.

Observe warnings and precautions to ensure device safety.

Check that device safety is ensured, and manufacture a safe device.



Warning

① **This product is designed and manufactured as a general industrial machine part. It must be handled by an operator having sufficient knowledge and experience in handling.**

② **Use this product in accordance of specifications.**

Contact CKD when using the product outside the unique specifications range, when using it outdoors, and when using it under the conditions and environment below.

Do not attempt to modify or additionally machine the product.

(1) Use for special applications requiring safety including nuclear energy, railroad, aviation, ship, vehicle, medical equipment, or applications coming into contact with beverage or food, amusement equipment, emergency shutoff circuits, press machine, brake circuits, or for safeguard.

(2) Use for applications where life or assets could be adversely affected, and special safety measures are required.

③ **Observe corporate standards and regulations, etc., related to the safety of device design and control, etc.**

ISO 4414, JIS B 8370 (pneumatic system rules)

JPAS 005 (policy for pneumatic cylinder use and selection)

High Pressure Gas Maintenance Laws Occupational Safety and Sanitation Laws, and other safety rules, association standards and regulations.

④ **Do not handle, pipe, or remove devices before confirming safety.**

(1) Inspect and service the machine and devices after confirming safety of the entire system related to this product.

(2) Note that there may be hot or charged sections even after operation is stopped.

(3) When inspecting or servicing the device, turn off the energy source (air supply or water supply), and turn off power to the facility. Discharge any compressed air from the system, and pay enough attention to possible water leakage and leakage of electricity.

(4) When starting or restarting a machine or device that incorporates pneumatic components, make sure that the system safety, such as pop-out prevention measures, is secured.

⑤ **Observe warnings and cautions on the pages below to prevent accidents.**

■ The Safety cautions are ranked as "DANGER", "WARNING" and "CAUTION" in this section.



DANGER: When a dangerous situation may occur if handling is mistaken leading to fatal or serious injuries, or when there is a high degree of emergency to a warning.



WARNING: When a dangerous situation may occur if handling is mistaken leading to fatal or serious injuries.



CAUTION: When a dangerous situation may occur if handling is mistaken leading to minor injuries or physical damage.

Note that some items described as "CAUTION" may lead to serious results depending on the situation. In any case, important information that must be observed is explained.

DESIGN AND SELECTION



DANGER:

■ WORKING FLUID

- Never use with a flammable fluid.

■ WORKING ENVIRONMENT

- Explosion-proof environments Never use this product in an explosive gas atmosphere. The structure is not explosion-proof, and explosions or fires could occur.

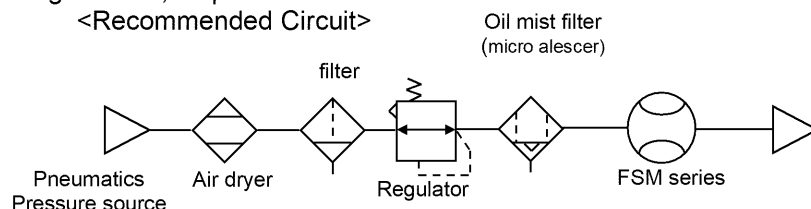


WARNING:

■ WORKING FLUID

- This product cannot be used as a billing meter.
Do not use this product for commercial transactions as it is not compliant with the Measurement Act. Intended applications include industrial sensors.
- This flow sensor is designed for air. Only dry air, N₂ are applicable.
Do not use fluids other than the applicable fluids, because accuracy cannot be guaranteed.
- Use dry gas which does not contain corrosive elements such as chlorine, sulfur or acids, and which is clean and does not contain dust or oil mist.
- As compressed air from the compressor contains drainage (water, oil oxides, foreign matter, etc.), install a filter, air dryer, and oil mist filter (micro alescerc) on the primary side (upstream side) of the sensor. The sensor's mesh rectifies flow in the pipe. It does not filter out foreign matter, so provide a filter.

<Recommended Circuit>



- When using a valve on the primary side of the sensor, use only valves with oil-prohibited specifications. This sensor could malfunction or fail if exposed to splattering grease, oil, etc. As friction powder may be generated depending on the valve, mount a filter to prevent the powder from entering the sensor
- Depending on the fluid, retaining the fluid for a long time could adversely affect the performance. Do not seal the fluid in the pipe for long periods of time.
- Use the product in accordance with specifications.
If used out of the maximum working pressure and minimum working pressure, working flow range, the product may result in failures.

■ WORKING ENVIRONMENT

- Corrosive environments
Do not use this product in an atmosphere containing corrosive gases such as sulfur dioxide.
- Ambient / fluid temperatures
Use at ambient / fluid temperatures within the specified range of 0 to 50°C. Even if the temperature is within the specified range, do not use this product if the ambient / fluid temperatures could suddenly change and cause dew to condense.
- Working pressure/flow rate range
Applications exceeding the max. working pressure and specified flow rate range may result in faults. Use this product only within the specified range.

● **Drip-proof environment**

The degree of protection of this product is equivalent to IP40. Do not install this product where water, salt, dust, or swarf is present or in a pressurized or depressurized environment. The product cannot be used with large temperature variations or high temperature/humidity since condensation may occur inside the body.



CAUTION:

■ **FLOW RATE UNIT**

- This product's flow rate is measured at a mass flow rate unaffected by temperature or pressure. The unit is L/min., but this is the display when the mass flow rate is converted to volumetric flow rate at 20°C 1 barometric pressure (101 kPa) relative humidity 65 %

■ **OVREFLOW**

- With each series, the sensor can handle an overflow double the measured range. If dynamic pressure is applied near the maximum working pressure (when pressure is applied to the primary side with the secondary side open), the sensor may operate abnormally. If dynamic pressure is applied, such as when a workpiece is filled for leakage inspection, provide a bypass circuit or restrictor so that dynamic pressure is not applied to the sensor.

■ **Use for suction confirmation, etc.**

- When this product is used to confirm suction, etc., select the flow rate range based on the operating vacuum pressure and suction nozzle. Refer to "4. Technical data Methods for calculating theoretical flow rate".
- When this product is used to confirm suction, etc., provide an air filter (filtration rating 30 µm or less) upstream from suction to prevent the entry of foreign matter.
- When this product is used to confirm suction, etc., consider the atmospheric dew point and the product's ambient temperature, and use the product under conditions in which dew does not condense in pipes.
- When this product is used to confirm suction, etc., response time may be delayed by the piping volume between the suction nozzle and this product. In this case, take countermeasures to reduce piping capacity.
- Do not bend the tube near the push-in fitting. If stress is applied to the tube near the push-in fitting, insert an insert ring into the tube, and connect the tube to the push-in fitting.

■ **Working conditions for CE compliance**

This product is CE-marked, indicating conformity with the EMC Directives. The standard for the immunity for industrial environments applied to this product is EN61000-6-2; the following requirements must be satisfied in order to conform to this standard:

<Conditions>

- The assessment of this product is performed by using a cable pairing a power supply line and a signal line, assessing this cable as a signal line.
- This product is not equipped with surge immunity. Implement surge protection measures on the system side.

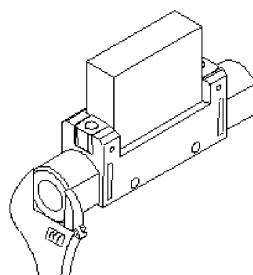
INSTALLATION & ADJUSTMENT



CAUTION:

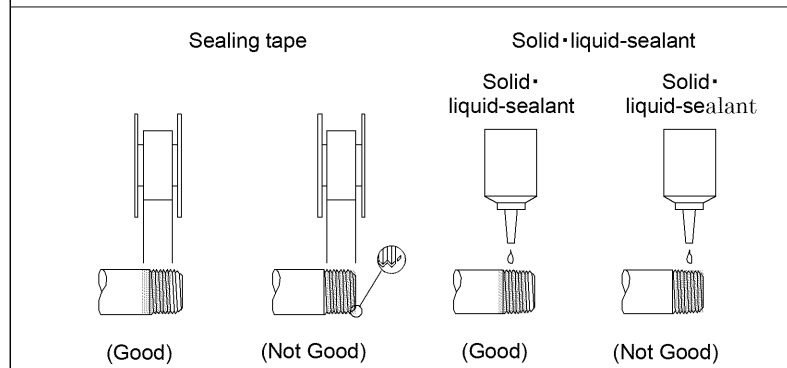
■ PIPING

- Pipe based on the fluid direction and the direction indicated on the device.
- Arrange piping so that the flow direction agrees with the direction of the arrow indicated on the sensor body.
Insert 4mm tube to one-touch fitting.
The tube must be inserted certainly, Pulls the tube to check that the tube not be come out.
Before inserting the tube, make sure to cut it in a right angle by a dedicated cutter.
- When piping, apply a spanner on two flat spaces of the metal section not to apply forces onto the resin section.
When installing the sensor on piping, that excessive screw-in torque or load torque is not applied to the connection port.



- Before installing piping, clean out the pipes using air blower to remove all foreign matter and cutting chips from the pipes. The rectifier or sensor chip could be damaged if a large amount of foreign matter, cutting chips, etc., enters.
- Make sure that no sealing tape or adhesive enters the pipes when connecting the piping.

When winding fluoro resin sealing tape around threads, wind the sealing tape once or twice, leaving 2 to 3 threads open at the end of the screw. Press the tape with your fingernail to stick it onto threads. When using liquid sealant, leave one to two threads open from the end, and avoid applying too much. Check that the sealant does not get on device threads.



- Flow characteristics may be varied according to flow path structure. If connection block is used make sure the flow rate and the output characteristics before use.
(Refer to desirable dimensions A3-451176)

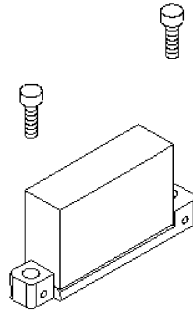


CAUTION:

■ MOUNTING

- This product can be installed in any direction; top, bottom, left, or right.

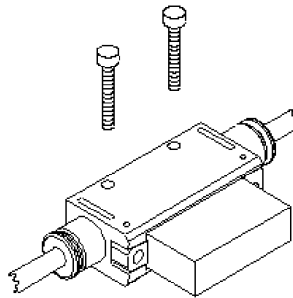
< For discrete sensor head >



M2

Tightening torque: 0.2 N·m to 0.3 N·m
(Attached, Recommended screw size)

<For flow path block attached>



M1.6

Tightening torque: 0.2 N·m to 0.3 N·m
(Not attached, Recommended screw size)



DANGER:

■ **WIRING**

- Use power supply voltage and output within the specified voltage. If voltage exceeding the specified voltage is applied, the sensor could malfunction or be damaged, or electrical shock or fire could occur. Do not use any load that exceeds the rated output. Otherwise, output damage or fire may result.



WARNING:

■ **WIRING**

- Stop the control device and equipment and turn power OFF before wiring.
- Check line color when wiring. As incorrect wiring could result in sensor damage and malfunctions, check wire color against the instruction manual before wiring.
- Ensure that wires are properly insulated.
Check that wires do not come into contact with other circuits, that no ground faults occur, and that the insulator between terminals is not defective. Overcurrent could flow in and damage the sensor.
- Use a stabilized DC power supply within the specified rating that has been insulated from the AC power supply. A non-insulated power supply could result in electrical shock. If power is not stabilized, the peak value in summer could exceed the rating and damage the product or reduce precision.
- Install this product and wiring as far away as possible from sources of noise such as power distribution wires. Provide separate countermeasures for surge applied to the power cable.
- Please be careful to counter-currents and surge currents because this product may result in failures.
- Do not short-circuit the load. Failure to observe this could result in rupture or burning.
- The output impedance of the analog output section is approx. 1 kΩ. If the impedance of the connecting load is small, output error increases. Check error with the impedance of the connecting load before using.
- Make sure that the lead wire is free of repeated bends and tension. Failure to do so could lead to disconnection.
- Make sure that no external force is applied to the connector section during use. The internal base or body may be deformed, resulting in output deviation or external leakage.

DURING USE & MAINTENANCE



WARNING:

■ ADJUSTMENT

- Output accuracy is affected by temperature characteristics and heat generated when energized. Provide sufficient stand-by time (5 minutes or more after energizing) before use.
- In applications where failure of this product leads to serious accident, be sure to set up a fail-safe mechanism.



CAUTION:

- If a problem occurs during operation, immediately turn the power OFF, stop use, and contact your dealer.
- Keep this product's flow rate within the rated flow range.
- Use this product within the working pressure.
- The accuracy may vary from the initial status depending on the working environment or working conditions. It is recommended to check the operation of the product periodically.
- Do not stress this product when it does work. So output of fluid flow may change.
- Flow characteristics may be varied according to flow path structure. If connection block is used make sure the flow rate and the output characteristics before use. (Refer to desirable dimensions A3-451176)
- Do not disassemble or modify, as this may cause malfunction.
- The case is made of resin. Do not use solvent, alcohol or detergent in cleaning, or resin could absorb it. Wipe off dirt with a rag soaked in a diluted neutral detergent solution and wrung out well.

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Miniature flow rate switch RAPIFLOW□

FSM-X Series

Manual No. SM-451176

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1 INSTALLATION

1. INSTALLATION

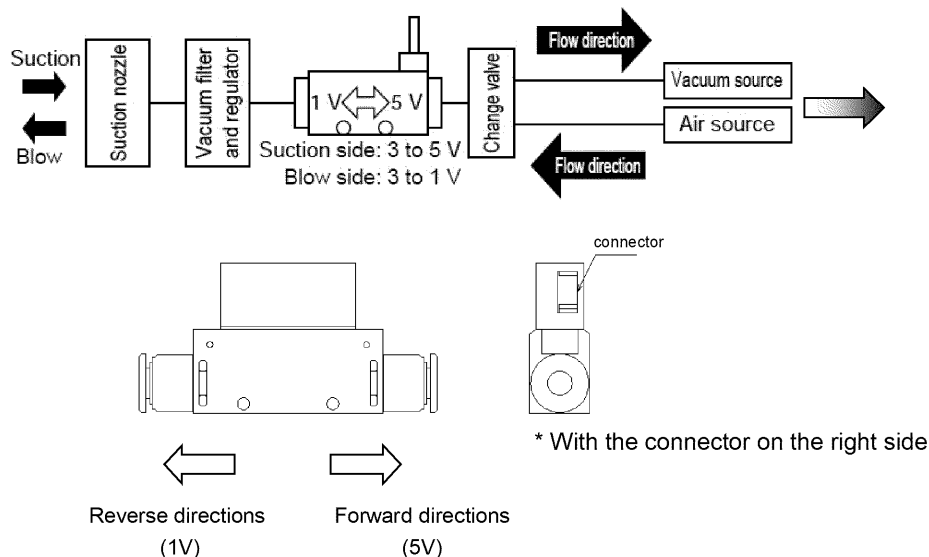
1. 1 Piping

<Caution>

Arrange piping so that the flow direction agrees with the direction of the arrow indicated on the sensor body.

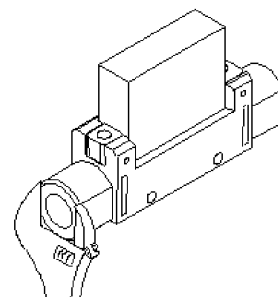
Example of piping (Bi-direction)

Suction side: Forward directions (3V to 5V), Blow side: Reverse directions (1V to 3V)

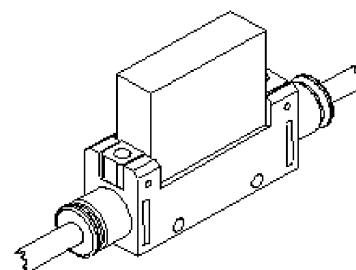


- Flash the pipe to remove foreign substances and swarf, etc., in inside of pipe before piping.
- When piping, apply a spanner on the metal section not to apply forces onto the resin section.
- Be careful not to grip and rotate the plastic case. When piping a sensor, do not apply excessive screw-in and load torques to the port.

Port thread	Tightening torque
M5	0.5 N·m to 1.0 N·m



- When piping, care must be taken that sealing tape and adhesive must not enter into the inside.
- If a push-in joint is used, the tube must be inserted certainly. Pulls the tube to check that the tube not be come out
- Cut the tube in right angle with the dedicated cutter.

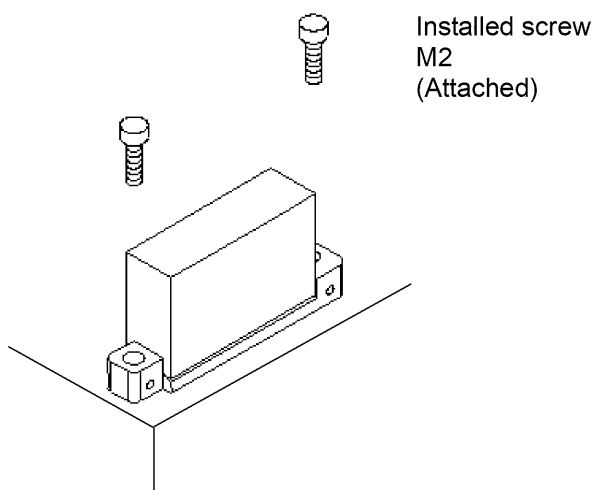


1. 2 Installation

● Sensor head

Install using the 2 through holes ($\varnothing 2.3$).

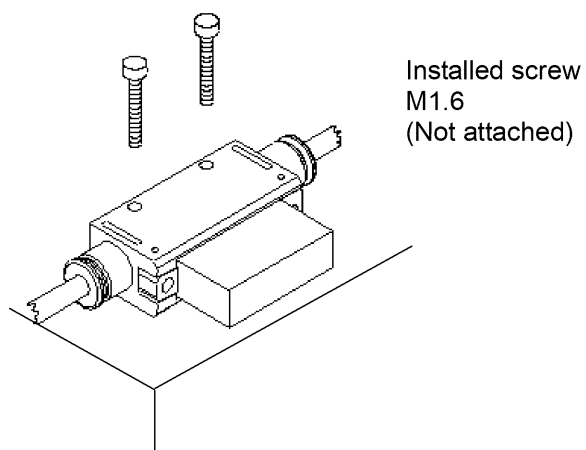
The tightening torque for screws should be 0.2 N·m to 0.3 N·m.



● For flow path block attached

Install using the 2 through holes ($\varnothing 2$).

The tightening torque for screws should be 0.2 N·m to 0.3 N·m.

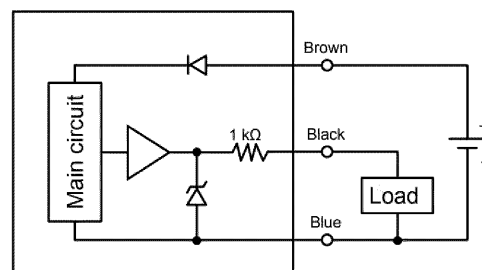


1 INSTALLATION

1. 3 Wiring

1. 3. 1 Analog output type

Line Color	Type of signal
Brown	Power supply + 24 VDC 24 VDC ripple rate 1% or less
Blue	Power supply - GND
Black	Analog output (1 V to 5 V) connected load impedance 50 kΩ and over



(Caution)

Connecting load

The output impedance of the analog output section is 1 kΩ. If the impedance of the connecting load is small, output error increases. Check error with the impedance of the connecting load before using.

■ Example of calculation

- Output impedance of FSM-X $R_o = 1\text{ k}\Omega$
- Output impedance of FSM-X $R_o = 1\text{ k}\Omega$
- Output value = $(1 - R_o/[R_o + R_x]) \times 100\% = (1 - [1\text{ k}\Omega/[1\text{ k}\Omega + 1\text{ M}\Omega]) \times 100\%$
⇒ Output value error = approx. 0.1%

Wiring resistance

The voltage used for this product is the voltage at the connector. When using the optional cable (FSM-X-C33), note that the voltage varies due to the cable wiring resistance (0.23 Ω/m or less).

■ Example of calculation

- Wiring resistance of optional cable (FSM-X-C33) (3 m): $0.23\text{ }\Omega/\text{m} \times 3\text{ m} = 0.69\text{ }\Omega$
- Voltage generated between power supply and wire = Current consumption of product
(=30 mA) $\times$ Wiring resistance $0.69\text{ }\Omega = \text{approx. } 0.02$
- Output value error = $0.02\text{ V}/4\text{ V (full scale)} = 0.5\% \text{ F.S.}$

2. MAINTENANCE

2. 1 TROUBLE SHOOTING

Trouble	cause	Corrective action
High amount of external leakage	Gasket shedding	Check if the gasket is in the groove
	Cracking gaskets	Gasket replacement
	The fixing screw is loose. (M2 screw, 2 places)	Check the tightening status of the screws
	Supply pressure is out of specification	Check the supply pressure (-90 kPa to 200 kPa)
	External force is applied to the main unit.	Check the cable is not pulled
		Check the main unit is not pushed from the outside.
	Poor connection of fittings (φ4 fittings)	Check the Tube Insertion Status
The output voltage does not work	Proof connection of fittings (M5 threads)	Check the screwing status
	Broken cable	Replace Cables
	Miswiring	Check the cable routing
	Poor connector connection	Check the mating status of the connector
	Power supply voltage is out of specification	Set to 24 VDC ± 10%
Defective output voltage (The zero point deviates from the specification value)	Malfunction of the main unit	Replace the main unit
	Foreign objects is stuck inside the flow path	Install the filter on the suction side
	Power supply voltage is out of specification	Set to 24 VDC ± 10%
Defective output voltage (The span point deviates from the specification value)	Malfunction of the main unit	Replace the main unit
	High amount of external leakage	Check for leaks in the piping on the suction side
	Supply pressure is out of specification	Check the supply pressure (-90 kPa to 200 kPa)
	Ambient temperature is out of specification	Check the ambient temperature (0°C to 50°C)
Low output voltage	Contamination of the sensor chip	Replace the main unit
	Low impedance of the connected load	Limit the impedance of the connected load to 50 kΩ or more
Analog output is not stable	Fluid wobble	Provide a buffer tank (when pressurized)
		Low pumping capacity of the vacuum source (at vacuum)
	Fluctuations in the power supply voltage	Check the power supply capacity
	Effects of Noise	Move the main unit and cable away from the noise source.



3. PRODUCTS

3. 1 Specifications

description \ Model no		Analog output type							
		FSM-X-AR005	FSM-X-AR010	FSM-X-AR050	FSM-X-AR100	FSM-X-AF005	FSM-X-AF010	FSM-X-AF050	FSM-X-AF100
Full scale rate (L/min) (*1)		-0.5 to +0.5	-1 to +1	-5 to +5	-10 to +10	0 to 0.5	0 to 1	0 to 5	0 to 10
Working condition	Working fluid (*2)	Clean air ISO 8573-1: 2010 [1: 1: 1 to 1: 6: 2], nitrogen							
	Maximum working pressure	0.2 MPa							
	Minimum working pressure	-0.09 MPa							
	Withstanding pressure	0.3 MPa							
	Ambient temperature/humidity	0°C to 5°C, 80% RH or less							
	Working fluid temperature	0°C to 50°C (no condensation)							
PRESERVATION TEMPERATURE		-20°C to 60°C (no condensation)							
Output		Analog output 1 point (1 V to 5 V voltage output, connected load impedance 50 kΩ and over) (*3)							
Accuracy (*4)	Linearity	Non-linear characteristics							
	Pressure characteristics	Bi-direction: ±5% F.S. or less (-0.09 MPa to 0.2 MPa, 0.1MPa reference) Uni-direction: ±10% F.S. or less (-0.09 MPa to 0.2MPa, 0.1MPa reference)							
	Temperature characteristics	Bi-direction: ±0.3%F.S./°C or less (0°C to 50°C, 25°C reference) Uni-direction: ±0.6%F.S. /°C or less (0°C to 50°C, 25°C reference)							
	Reproducibility (*5)	±2% F.S. or less							
Response time (*6)		5 ms or less (8 ms or less for 10 L/min)							
External leakage (*7)		1 mL/min or less (single sensor head), 2 mL/min (with flow path block)							
Current consumption (*8)		30 mA or less							
Power supply voltage		24 VDC (21.6 to 26.4 VDC) ripple rate 1% or less							
Power supply voltage fluctuation		±2%F.S. or less (21.6 V to 26.4 V)							
Connector	Product side	SM03B-SRSS-TB (JST Mfg. Co. Ltd.), without lock mechanism							
Compatible connector	Housing	SHR-03V-S (JST Mfg. Co. Ltd.)							
	Connector pin	SSH-003T-P0.2-H (JST Mfg. Co. Ltd.)							
Mounting	Mounting orientation	Unrestricted in vertical/horizontal direction							
	Straight piping section	Not required							
Straight piping section		10 to 150 Hz, compound amplitude 1.5 mm, max. 10 G, 2 hours per X, Y, Z direction							
Weight	Blank	Approx.4g (cable not included)							
	H04	Approx.17g (cable not included)							
	M05	Approx.17g (cable not included)							
EMC Directive		EN61000-6-4, EN61000-6-2							

*1: The value converted to volumetric flow rate 20°C 1 barometric pressure (101 kPa) relative humidity 65%.

*2: Use air which does not contain corrosive elements such as chlorine, sulfur or acids. When using compressed air, use clean air that complies with ISO 8573-1: 2010 Class [1: 1: 1 to 1: 6: 2]. Compressed air from the compressor contains drainage (water, oil oxides, foreign matter, etc.). To maintain the function of this product, install a filter, air dryer, and oil mist filter on the primary side (upstream side) of this product. When using this product to confirm suction, be sure to install an air filter between the suction nozzle and this product to prevent intake of foreign matter.

*3: The flow rate output of this product does not indicate the absolute value of the flow rate.

*4: Calibrate the sensor using uni-direction analog output of 1 to 5 V and bi-direction analog output of 3 to 5 V. Accuracy conditions: Temperature 25±3°C, power supply voltage 24±0.01 VDC F.S. is defined as analog output 1 to 5 V.

*5: The average value of data taken for 20 seconds at interval of 0.5 ms when flow rate is ON is determined as a measurement value for 1 time, and the repeatability is determined by 10 continuous ON/OFF times of the flow rate. Change over time is not included.

*6: The time required for the output to reach 80% of the full scale of flow rate after the flow is detected. The response time varies depending on the piping conditions.

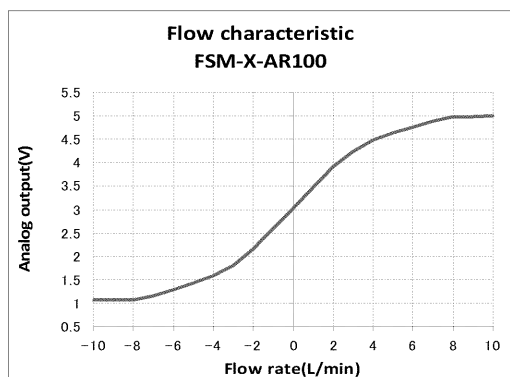
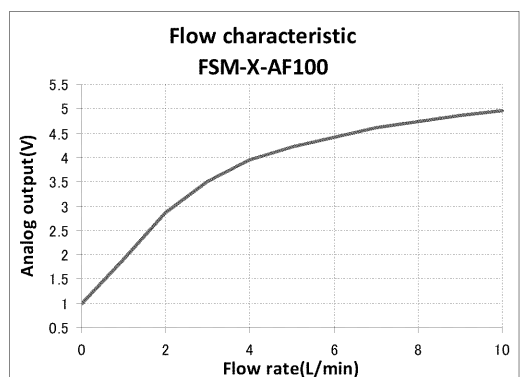
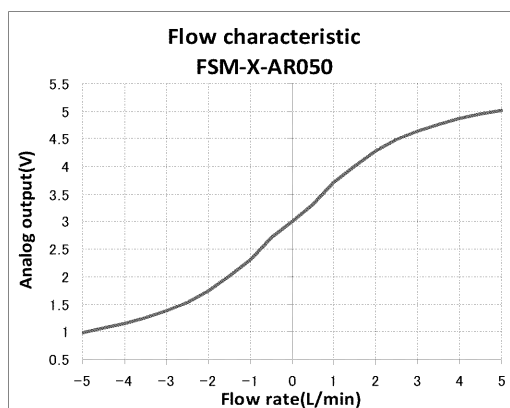
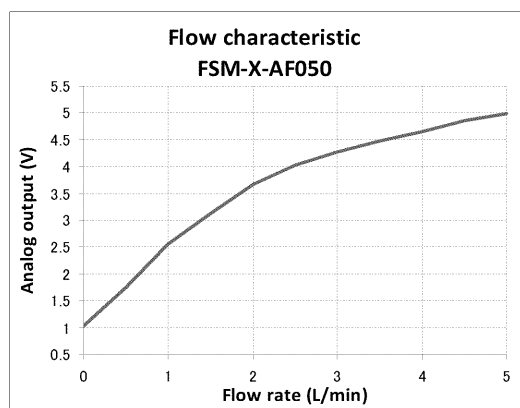
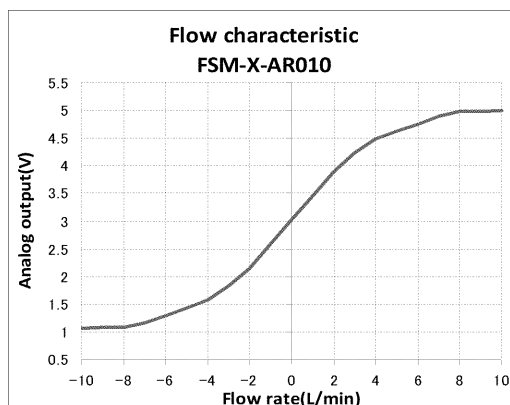
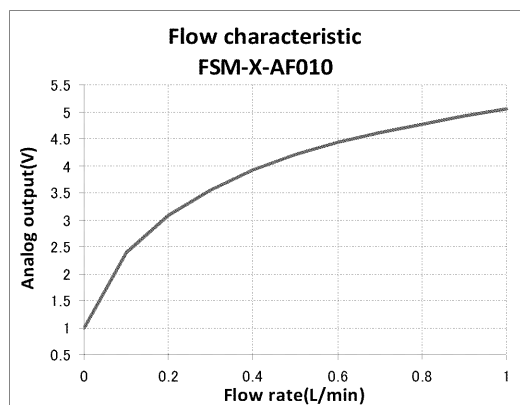
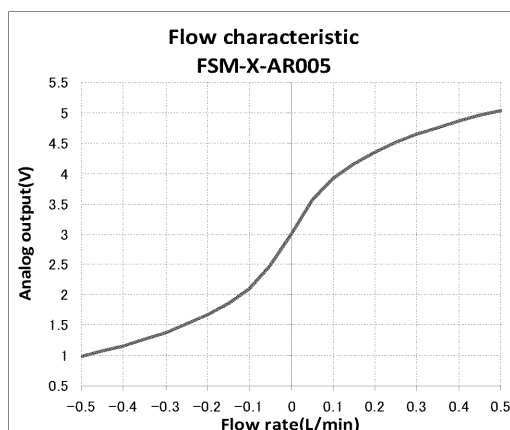
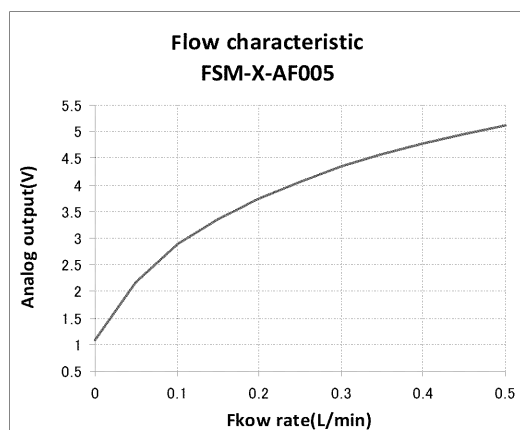
*7: The value obtained when an internal pressure of 0.2 MPa is applied in an environment of 25°C±3°C. It is an initial value, not including change over time.

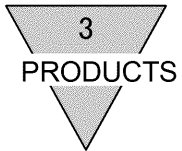
*8: Current for when 24 VDC is connected, and no load is connected. Note that the current consumption may vary depending on how the load is connected.

Analog output characteristics (reference value)

Uni-direction FSM-X-AF□□□

Bi-direction FSM-X-AR□□□





3. 2 How to order

F S M — X —
 A
R
0 0 5 —
 H 0 4 —
 3

①
②
③
④
⑤

①Output type		②Flow direction		③Flow rate (Full scale)	
A	Analog output: 1point (1 V to 5 V)	F	Uni-direction	005	0.5 L/min
		R	Bi-direction	010	1 L /min
				050	5 L /min
				100	10 L /min

④Fitting		⑤Cable option model	
Blank	Single sensor head (without fitting)	Blank	Without cable
H04	With flow path block (ø4 mm push-in fitting)	3	Cable with connector (3-conductor, 3 m)
M05	With flow path block (M5)		

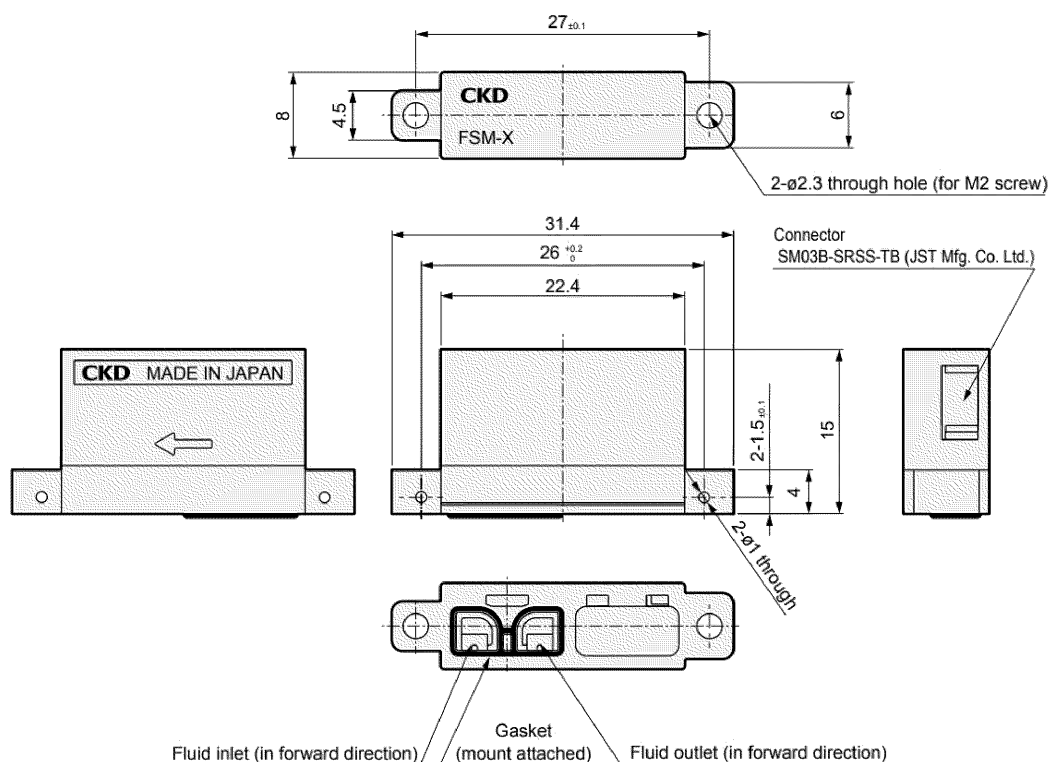
Options

F S M — X —
 C 3 3

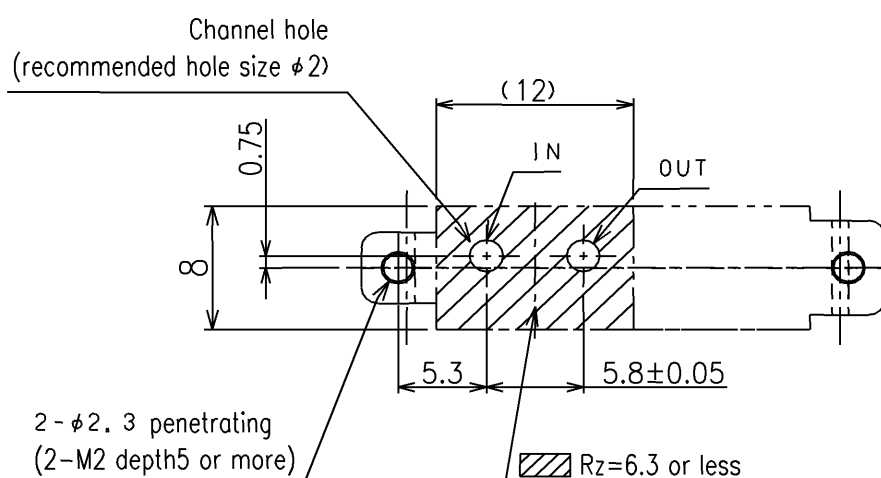
Option	
C33	Cable with connector (3-conductor, 3 m)

3. 3 Dimensions

3. 3. 1 Sensor head



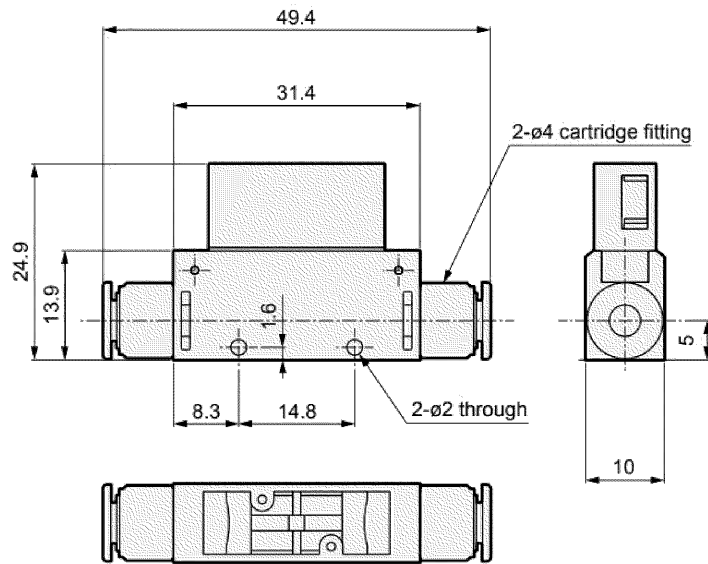
Recommended dimensions of connection block



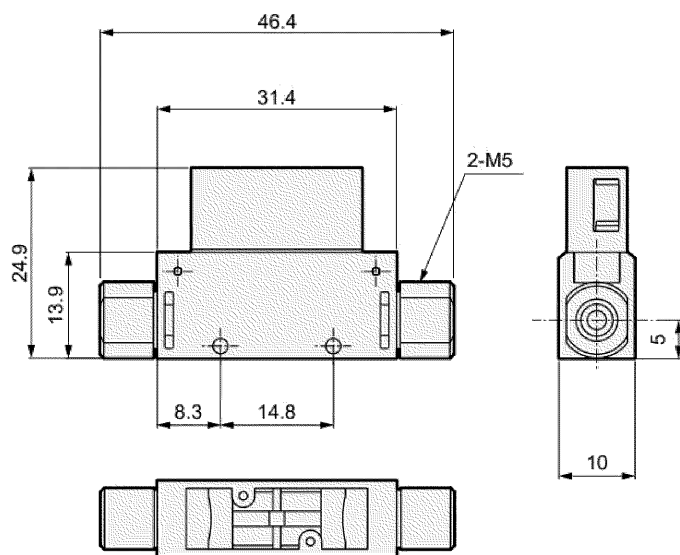
Flow characteristics may be varied according to flow path structure. If connection block is used make sure the flow rate and the output characteristics before use.

3. 3. 2 With channel block

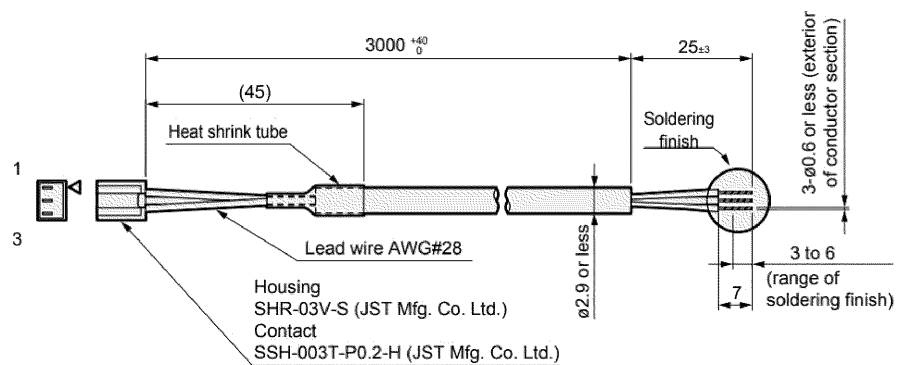
● With $\varnothing 4$ push-in fitting



● With M5



3. 3. 3 Cable option



Pin No.	Line	Type of signal
1	Brown	Power supply + 24 VDC
2	Blue	Power supply - GND
3	Black	Analog output (1 to 5 V)

4. Technical data

4. 1 Flow rate sensor selection method

- For $P_1 \geq 1.89P_2$ (acoustic velocity)

$$Q = 113.2 \times S \times P_1$$

- For $P_1 < 1.89P_2$ (subsonic velocity)

$$Q = 226.4 \times S \times \sqrt{P_2(P_1 - P_2)}$$

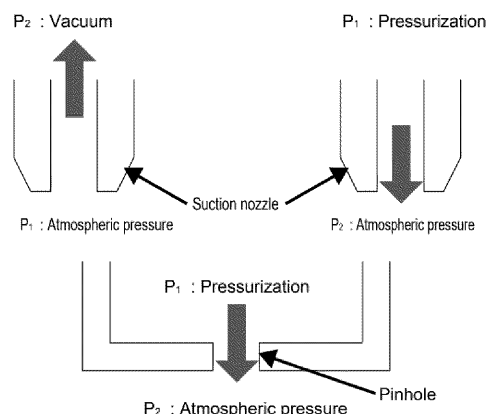
Q: Flow rate L/min

P₁: Primary side absolute pressure MPa

P₂: Secondary side absolute pressure MPa

S: Effective cross-sectional area of nozzle (pinhole) mm²

Use as a guideline for selection of the flow rate range when using the flow rate sensor for suction nozzle suction/release confirmation or leakage inspection. The flow rate can be calculated using the effective cross-sectional area of nozzle (pinhole) and the pressure difference inside and outside the nozzle.



Example of calculation

The calculated value of flow rate when the nozzle diameter is $\phi 0.1$ to 2 and P_2 is varied is shown in the figure below.

	P ₁ (MPa) Absolute pressure	P ₁ (MPa) Gauge pressure	P ₂ (MPa) Absolute pressure	P ₂ (MPa) Gauge pressure	Acoustic/ subsonic velocity	Calculated flow rete value (L/min)									
						φ0.1	φ0.2	φ0.3	φ0.4	φ0.5	φ0.7	φ1	φ1.5	φ2	
Vacuum	0.1013	0	0.0313	-0.07	Acoustic	0.090	0.360	0.810	1.440	2.250	4.411	9.002	20.254	36.007	
	0.1013	0	0.0413	-0.06	Acoustic	0.090	0.360	0.810	1.440	2.250	4.411	9.002	20.254	36.007	
	0.1013	0	0.0513	-0.05	Acoustic	0.090	0.360	0.810	1.440	2.250	4.411	9.002	20.254	36.007	
	0.1013	0	0.0613	-0.04	Velocity	0.088	0.352	0.792	1.408	2.200	4.312	8.800	17.249	35.202	
	0.1013	0	0.0713	-0.03	Velocity	0.082	0.329	0.740	1.315	2.055	4.028	8.220	16.110	32.878	
	0.1013	0	0.0813	-0.02	Velocity	0.072	0.287	0.645	1.147	1.792	3.512	7.166	14.046	28.666	
	0.1013	0	0.0913	-0.01	Velocity	0.054	0.215	0.483	0.859	1.343	2.631	5.370	10.525	21.480	
Blow (leakage inspection)	0.1113	0.01	0.1013	0	Velocity	0.057	0.226	0.509	0.905	1.414	2.772	5.657	11.087	22.626	
	0.1213	0.02	0.1013	0	Velocity	0.080	0.320	0.720	1.280	2.000	3.920	8.000	15.679	31.998	
	0.1413	0.04	0.1013	0	Velocity	0.113	0.453	1.018	1.810	2.828	5.543	11.313	22.174	45.252	
	0.1613	0.06	0.1013	0	Velocity	0.139	0.554	1.247	2.217	3.464	6.789	13.856	27.157	55.423	
	0.1813	0.08	0.1013	0	Velocity	0.160	0.640	1.440	2.560	4.000	7.840	15.999	31.358	63.996	
	0.2013	0.1	0.1013	0	Acoustic	0.179	0.716	1.610	2.862	4.472	8.765	17.888	40.248	71.552	
	0.3013	0.2	0.1013	0	Acoustic	0.268	1.071	2.410	4.284	6.694	13.119	26.774	60.242	107.096	
	0.4013	0.3	0.1013	0	Acoustic	0.357	1.426	3.209	5.706	8.915	17.474	35.660	80.236	142.641	
	0.5013	0.4	0.1013	0	Acoustic	0.445	1.782	4.009	7.127	11.137	21.828	44.547	100.230	178.186	
0.6013	0.5	0.1013	0	Acoustic	0.534	2.137	4.809	8.549	13.358	26.182	53.433	120.224	213.731		

(Caution)

- When there is a leakage in the piping, etc., the actual flow rate becomes larger than the calculated value. When selecting the flow rate, consider the amount of leakage in the piping.
- When there is a portion narrower than the suction nozzle diameter in the middle of the piping, the flow rate may be reduced to lower than the calculated value. In addition, suction confirmation, etc., may become impossible.
- The effective cross-sectional area is just a guideline. When the nozzle is long and thin, the effective cross-sectional area becomes smaller than the opening area.
- The response time is determined by the inner volume of the piping from the flow rate sensor to suction nozzle (pinhole). For high-speed detection, reduce the inner volume of the piping as much as possible by installing a flow rate sensor near the suction nozzle, etc.