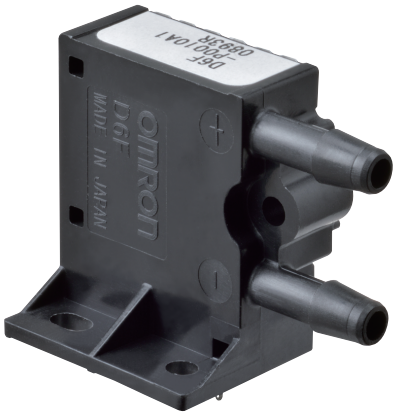
OMRON

MEMS Flow Sensor

D6F-P

User's Manual

MEMS Flow Sensor



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Contents

1. Overview

This User's Manual describes usage of and interface with OMRON's MEMS flow sensor (D6F-P). It should be noted that this document is intended to supplement the datasheet, which should be referenced when using the sensor.

2. Product lineup

Table 1 shows the MEMS flow sensor (D6F-P) lineup and Table 2 accessories (optional).

Table 1 Lineup

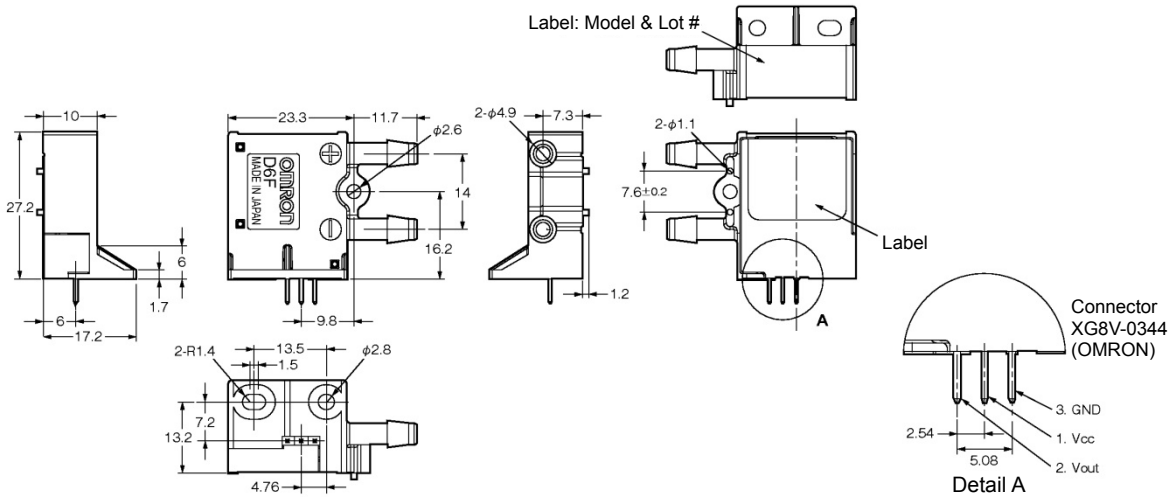
Flow range	Port type	Connection	Model
0 to 0.1 L/min	Bamboo	Implemented on PCB	D6F-P0001A1
0 to 1 L/min			D6F-P0010A1
		Connector	D6F-P0010A2
	Manifold	Connector	D6F-P0010AM2

Table 2 Accessories (optional)

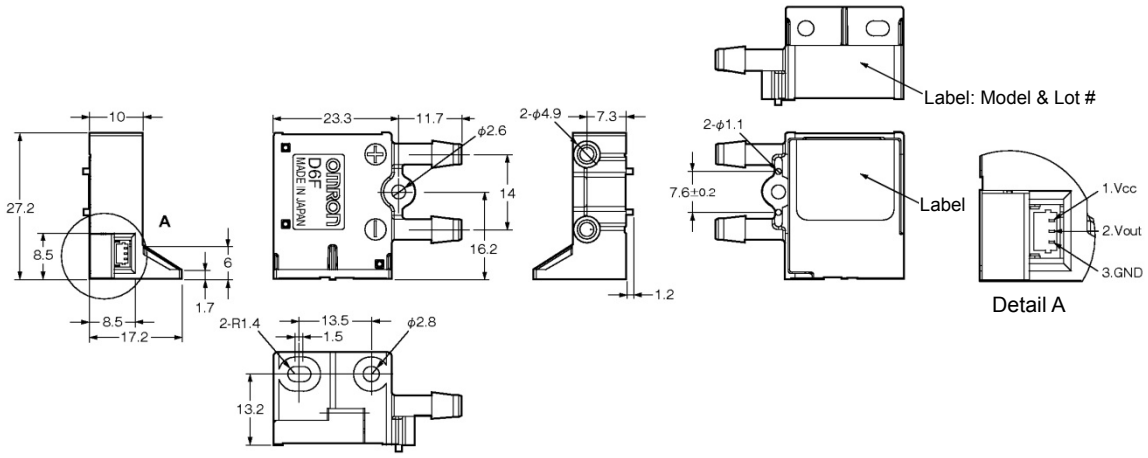
Type	Model
Cable	D6F-CABLE2
	D6F-CABLE2-L

3. Dimensions

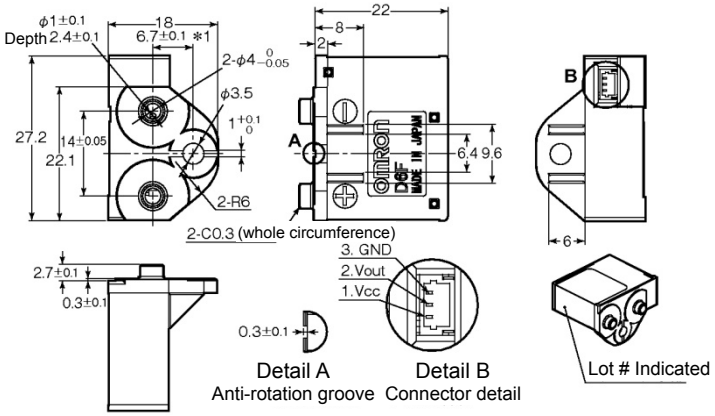
3.1 PCB Implementation (Model: D6F-P0001A1/-P0010A1)



3.2 Connector (Model: D6F-P0010A2)



3.3 Connector (Model: D6F-P0010AM2)



Use connectors of J.S.T. Mfg. Co., Ltd. for those that are connected to this product.
Press-fit connector

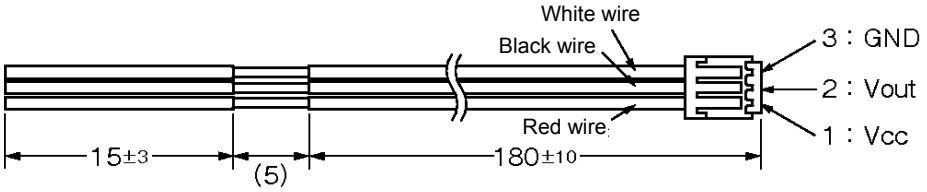
Socket	: 03SR-3S
Wire	: AWG#30

Crimping connector

Contacts	: SSH-003T-P0.2
Housing	: SHR-03V-S
Wire	: AWG#32 to #28

3.4 Accessories (optional)

D6F-CABLE2



Contacts	: SSH-003T-P0.2 (J.S.T. Mfg. Co., Ltd.)
Housing	: SHR-03V-S (J.S.T. Mfg. Co., Ltd.)
Wire	: AWG#30

D6F-CABLE2-L

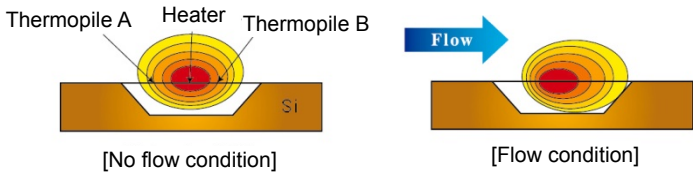
A model with the total length of D6F-CABLE2 as 2000 (mm).

Contacts	: SSH-003T-P0.2 (J.S.T. Mfg. Co., Ltd.)
Housing	: SHR-03V-S (J.S.T. Mfg. Co., Ltd.)
Wire	: AWG#30

4. Operating Principle

MEMS flow sensor (D6F-P) is a thermal mass flow sensor.

A silicon substrate has a heater and thermopiles on both sides of it on the thin film formed on the substrate, which detects heat transfer as changes of air flow on it to measure the flow rate.



[No flow condition] [Flow condition]

5. Features of Product

Micro-flow rate can be measured

By using a thermal mass flow method, OMRON's MEMS flow sensor (D6F-P) can measure low flow rate. (Measurement of flow rate from 0 to 0.1 L/min is available[*1])

*1 In case of D6F-P0001A1

High dust resistance

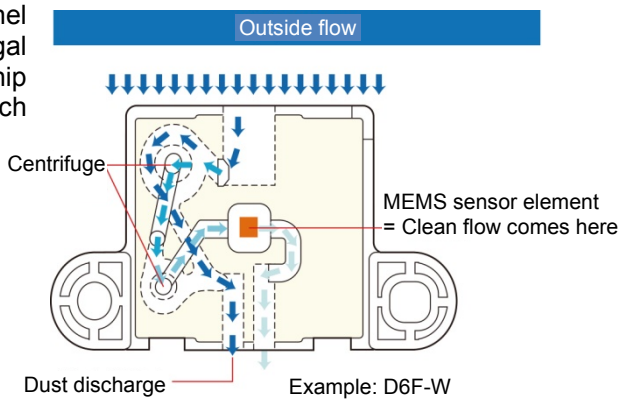
Can be used in dusty environment by its structure (DSS[*2]) that helps prevent dust in fluid from adhering to the sensor. (Avoid dust around the air inlet)

Lineup

Selection of two port types and two connection types available.

*2 DSS (Dust Segregation Structure)

Air coming from outside is divided into a spiral channel and a core channel. Dust is separated by the centrifugal force caused by the helical structure, and the sensor chip is supplied with a gas that contains almost no dust, which can reduce contamination.



6. Main Specifications
6.1 Feature & Rating

Table 3 Main Features of D6F-P□□□□

Model	D6F-P0001A1	D6F-P0010A1	D6F-P0010A2	D6F-P0010AM2
Flow range*1	0 to 0.1 L/min	0 to 1 L/min		
Calibration Gas*2	Air			
Flow Port Type	Bamboo joint, maximum outside diameter: 4.9 mm, minimum outside diameter: 4.0 mm			Manifold
Electrical Connection	Lead terminal		Three-pin connector	
Power Supply	4.75 to 5.25 VDC			
Current Consumption	15 mA max. with no load and a Vcc of 5.0 V			
Output Voltage	0.5 to 2.5 VDC (Load resistance: 10kΩ)			
Accuracy	±5%FS (25°C characteristic)			
Repeatability*3	±1.0%FS	±0.4%FS		
Output voltage (Max.)	3.1 VDC (Load resistance: 10kΩ)			
Output voltage (Min.)	0 VDC (Load resistance: 10kΩ)			
Rated Power Supply Voltage	10 VDC			
Rated Output Voltage	4 VDC			
Case	PBT			
Degree of Protection	IEC IP40 (Excluding tubing sections.)			
Withstand Pressure *3	50 kPa			
Pressure Drop*3	0.005 kPa	0.19 kPa		0.67 kPa
Operating Temperature*4	−10 to +60°C			
Operating Humidity*4	35% to 85%			
Storage Temperature*4	−40 to +80°C			
Storage Humidity*4	35% to 85%			
Temperature Characteristics	±5% FS for 25°C characteristic at an ambient temperature of −10 to +60°C			
Insulation Resistance	Between Sensor outer cover and lead terminals: 20 MΩ min. (at 500 VDC)			
Dielectric Strength	Between Sensor outer cover and lead terminals: 500 VAC, 50/60 Hz min. for 1 min (leakage current: 1 mA max.)			
Weight	8.5 g		8.0 g	

*1. Volumetric flow rate at 0°C, 101.3 kPa.
*2. Dry gas. (must not contain large particles, e.g., dust, oil, or mist.)
*3. Reference (typical)
*4. With no condensation or icing.

Casing material: PBT, flammability UL94 standard: V-0

6.2 Output Voltage Characteristics

D6F-P0001A1

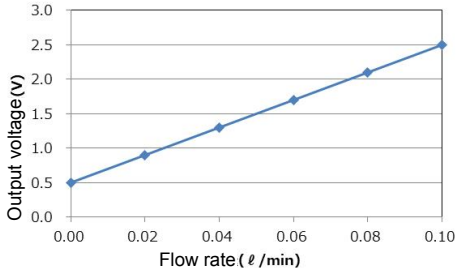


Table 4 Output characteristics of D6F-P0001A1

Flow rate L/min (Normal)	0	0.02	0.04	0.06	0.08	0.10
Output voltage (V)	0.50 ±0.10	0.90 ±0.10	1.30 ±0.10	1.70 ±0.10	2.10 ±0.10	2.50 ±0.10

D6F-P0010A1/-P0010A2/-P0010AM2

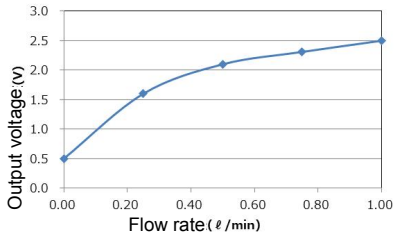


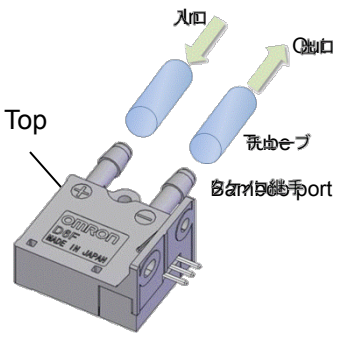
Table 5 D6F-P0010A1/-P0010A2/-P0010AM2

Flow rate L/min (Normal)	0	0.25	0.50	0.75	1.00
Output voltage (V)	0.50 ±0.10	1.60 ±0.10	2.10 ±0.10	2.31 ±0.10	2.50 ±0.10

7. Connection

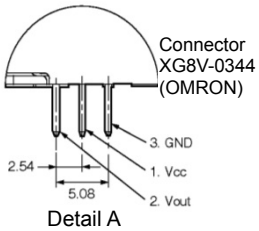
7.1 Low flow rate measurement

To measure 0.1(L/min) using D6F-P0001A1 or 1(L/min) using D6F-P0010A1 or D6F-P0010A2, connect the sensor with the bamboo port directly to the tube.

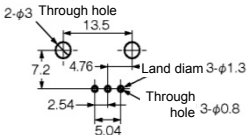


It is recommended to use an urethane tube with inner diameter of Φ 4(mm) and outer diameter of Φ6(mm).

The sensor should be placed so that its OMRON log mark should be facing up. (Left)



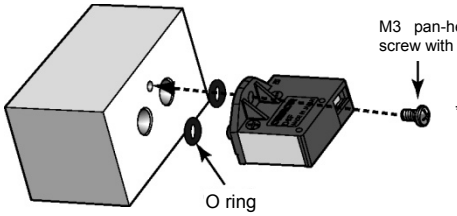
Detail A



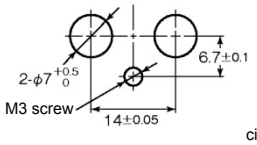
Recommended connector hole size (Back side)

Solder condition: Use a soldering iron with pressing force of 100g or less at temperature of 350℃ for 5 seconds (for PCB implementation type only)

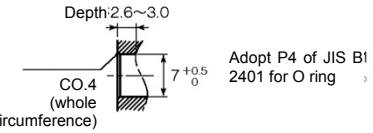
To measure 1(L/min) using D6F-P0010A2, connect the sensor with the manifold directly to the tube.



*1. Recommended installation size



Recommended O ring hole processing size



Fluid inlet and outlet must be sealed with an O ring for attachment.

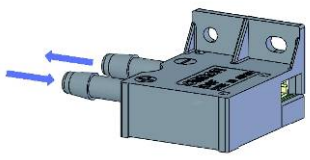
The recommended O ring is designation P4 (JIS B2401).

Sensor installation

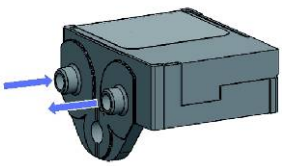
The sensor should be placed in the direction shown below, within a range of ±5° (all directions).

● Installation direction

PCB implementation type



Manifold type



7.2 High Flow Rate Measurement
D6F-P series sensor can measure high flow rate using a bypass configuration.

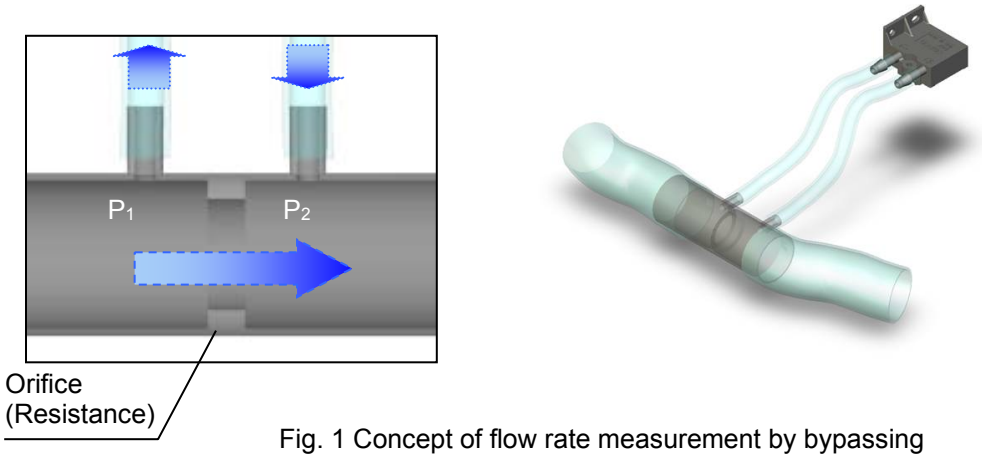


Fig. 1 Concept of flow rate measurement by bypassing

As shown in Fig.3, high flow rate can be measured by bypassing the flow to the sensor with an orifice (resistance) in the main flow path.

7.3 Orifice Diameter
Orifices are stipulated by JIS Z 8762-2:2007 (ISO 5167-2:2003).
The relationship between flow rate and pressure difference by orifice can be derived from Bernoulli's theorem.

$$Q = \alpha \varepsilon A \sqrt{\frac{2\Delta p}{\rho}}$$

where

$\alpha = \frac{C}{\sqrt{1-\beta^4}}$, $\varepsilon = 1 - \frac{(0.41-0.35\beta^4)}{\kappa}\frac{\Delta p}{p_1}$, $A = \frac{\pi}{4}d^2$

ρ: Density, C: Runoff coefficient, β: Diameter ratio (=d/D), κ: Isentropic index, p1: Upstream pressure of orifice, d: Orifice (resistance) diameter, D: Tube diameter

As the runoff coefficient C is a function of the diameter ratio and the Reynolds number, the equation (1) requires iteration, while approximation generally uses 0.6.

Based on this, Table 6 in the next page shows the calculation result of the orifice diameter.
Note that this is only a rough estimation and that actual value must be evaluated by the customer.

Table 6 Orifice diameter (d(mm))

D6F-P0001A1

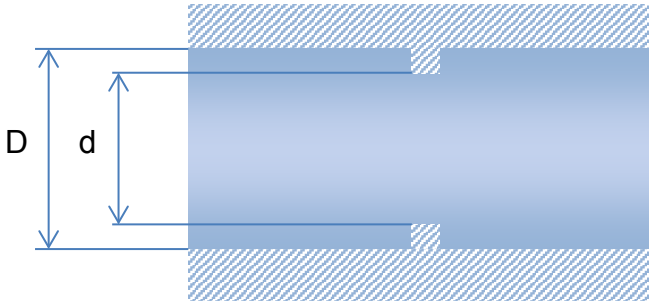
Flow rate	(L/min)	2	3	5	10	15	20
	(m^3/h)	0.12	0.18	0.30	0.60	0.90	1.20
D(mm)	10	4.27	5.18	6.48	8.24	9.00	9.38
	20	4.30	5.27	6.78	9.50	11.46	12.97
	30	4.31	5.27	6.80	9.60	11.72	13.47
	40	4.31	5.27	6.81	9.62	11.77	13.57
	50	4.31	5.27	6.81	9.62	11.78	13.60

D6F-P0010A1
D6F-P0010A2

Flow rate	(L/min)	10	20	30	50	100	150
	(m^3/h)	0.6	1.2	1.8	3.0	6.0	9.0
D(mm)	10	3.76	5.24	6.28	7.63	9.05	9.52
	20	3.78	5.34	6.53	8.39	11.61	13.75
	30	3.78	5.35	6.55	8.44	11.89	14.45
	40	3.78	5.35	6.55	8.45	11.94	14.58
	50	3.78	5.35	6.55	8.46	11.95	14.62

D6F-P0010AM2

Flow rate	(L/min)	10	20	30	50	100	150
	(m^3/h)	0.60	1.20	1.80	3.00	6.00	9.00
D(mm)	10	2.83	3.98	4.83	6.10	7.91	8.77
	20	2.83	4.00	4.90	6.31	8.86	10.73
	30	2.83	4.00	4.90	6.32	8.93	10.91
	40	2.83	4.00	4.90	6.33	8.94	10.94
	50	2.83	4.00	4.90	6.33	8.95	10.95



8. Troubleshooting

Q: The sensor output is nonlinear. It there an approximate expression of output characteristics?
A: Table 7 shows the approximate expression. Note that this expression is a polynomial approximation of the representative curve.

Approximation: Flow rate = $Ax^5 + Bx^4 + Cx^3 + \mathrm{D}x^2 + Ex + F$ (x: Voltage)

Table 7 Approximation coefficients

	Model	
Coefficient	D6F-P0001A1	D6F-P0010A1 D6F-P0010A2 D6F-P0010AM2
A:		0.094003
B:		-0.564312
C:		1.374705
D:		-1.601495
E:	49.944	1.060657
F:	-24.864	-0.269996

Q: What happens if the flow exceeds the maximum flow rate of the sensor?
A: Output becomes maximum output of 3.1 V. The output stays at this value even if the flow rate exceeds the maximum value.
The sensor will not be broken.

Q: What happens if the flow is reversed on the sensor?
A: Output voltage becomes 0.5 V or less, and no output at 0 V.

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Attention is required to the following points on descriptions in catalogues.

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(2) Please confirm fitness of Omron products in your application and use your own judgment to determine the appropriateness of using them in such application. Omron shall not warrant the fitness of Omron products in customer application.

(3) Please confirm that Omron products are properly wired and installed for their intended use in your overall system.

(4) When using Omron products, please make sure to (i) maintain a margin of safety vis-à-vis the published rated and performance values, (ii) design to minimize risks to customer application in case of failure of Omron products, such as introducing redundancy, (iii) introduce system-wide safety measures to notify risks to users, and (iv) conduct regular maintenance on Omron products and customer application.

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(c) Modification or repair made to the Omron products by other than Omron personnel.
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