Honeywell

Short Port Fastener Mount

Long Port Fastener Mount

Short Port Snap Mount

Honeywell Zephyr™ Digital Airflow Sensors: HAF Series – High Accuracy

±50 SCCM to ±750 SCCM

DESCRIPTION

Honeywell Zephyr™ HAF Series sensors provide a digital interface for reading airflow over specified full-scale flow and compensated temperature ranges. The thermally isolated heater and temperature sensing elements help these sensors provide a fast response to air or gas flow.

Zephyr sensors are designed to measure mass flow of air and other non-corrosive gases. Standard flow ranges are available at ±50, ±100, ±200, ±400 or ±750 SCCM. Custom flow ranges are also available. The sensors are fully calibrated and temperature compensated with an onboard Application Specific Integrated Circuit (ASIC).

The HAF Series is compensated over the temperature range of 0 °C to 50 °C [32 °F to 122 °F] and operates across a temperature range of -20 °C to 70 °C [-4 °F to 158 °F]. The state-of-the-art ASIC-based compensation provides digital (I^2C) outputs with a response time of 1 ms.

These sensors operate on the heat transfer principle to measure mass airflow. They consist of a microbridge Microelectronic and Microelectromechanical System (MEMS) with temperature-sensitive resistors deposited with thin films of platinum and silicon nitride. The MEMS sensing die is located in a precise and carefully designed airflow channel to provide repeatable response to flow.

Zephyr sensors provide the customer with enhanced reliability, high accuracy, repeatable measurements and the ability to customize sensor options to meet many specific application needs. The combination of rugged housings with a stable substrate makes these products extremely robust. They are designed and manufactured according to ISO 9001 standards.

FEATURES AND BENEFITS (★= competitive differentiator)

- ★ Total Error Band (TEB) as low as ±0.25 %FSS allows for precise airflow measurement, often ideal for demanding application with high accuracy requirements
- ★ Fast response time allows a customer's application to respond quickly to airflow change, important in critical medical (e.g., anesthesia) and industrial (e.g., fume hood) applications
- ★ Wide range of airflows: Zephyr measures mass flow at standard flow ranges of ±50, ±100, ±200, ±400 or ±750 SCCM, or custom flow ranges, increasing the options for integrating the sensor into the application
- ★ Customizable flow ranges and configurable package styles meet specific end-user needs
- Full calibration and temperature compensation typically allow customer to remove additional components associated with signal conditioning from the PCB, reducing PCB size as well as costs often associated with those components (e.g., acquisition, inventory, assembly)
- High sensitivity at very low flows provides for faster response time at the onset or cessation of flow
- ★ Linear output provides more intuitive sensor signal than the raw output of basic airflow sensors, which can help reduce production costs, design, and implementation time
- ★ High stability reduces errors due to thermal effects and null shift to provide accurate readings over time, often eliminating need for system calibration after PCB mount and periodically over time
- ★ Low pressure drop typically improves patient comfort in medical applications, and reduces noise and system wear on other components such as motors and pumps
- High 12-bit resolution increases ability to sense small airflow changes, allowing customers to more precisely control their application
- Low 3.3 Vdc operating voltage option and low power consumption allow for use in battery-driven and other portable applications
- ASIC-based I^2C digital output compatibility eases integration to microprocessors or microcontrollers, reducing PCB complexity and component count
- Insensitivity to mounting orientation allows customer to position sensor in most optimal point in the system, eliminating concern for positional effects
- Insensitivity to altitude eliminates customer-implemented altitude adjustments in the system, easing integration and reducing production costs by not having to purchase additional sensors for altitude adjustments
- Small size occupies less space on PCB, allowing easier fit and potentially reducing production costs; PCB size may also be reduced for easier fit into space-constrained applications
- RoHS-compliant materials meet Directive 2002/95/EC

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POTENTIAL APPLICATIONS

Medical
- Anesthesia delivery machines
- Ventricular assist devices (heart pumps)
- Hospital diagnostics (spectrometry, gas chromatography)
- Nebulizers
- Oxygen concentrators
- Patient monitoring systems (respiratory monitoring)
- Sleep apnea machines
- Spirometers
- Ventilators
- Laparoscopy

Industrial
- Air-to-fuel ratio
- Analytical instrumentation (spectrometry, chromatography)
- Fuel cells
- Gas leak detection
- VAV system on HVAC systems
- Gas meters
- HVAC filters

Table 1: Absolute Maximum Ratings[1]

Characteristic	Parameter
Supply voltage	-0.3 Vdc to 6.0 Vdc
Voltage on output pin	-0.3 V to Vsupply
Storage temperature range	-40 °C to 125 °C [-40 °F to 257 °F]
Maximum flow change	5.0 SLPM/s
Maximum common mode pressure	25 psi at 25 °C [77 °F]
Maximum flow	10 SLPM

Note 1: Absolute maximum ratings are the extreme limits that the device will withstand without damage to the device. However, the electrical and mechanical characteristics are not guaranteed as the maximum limits (above recommended operating conditions) are approached, nor will the device necessarily operate at absolute maximum ratings.

CAUTION

IMPROPER USE

Do not use these products to sense liquid flow.

Failure to comply with these instructions may result in product damage.

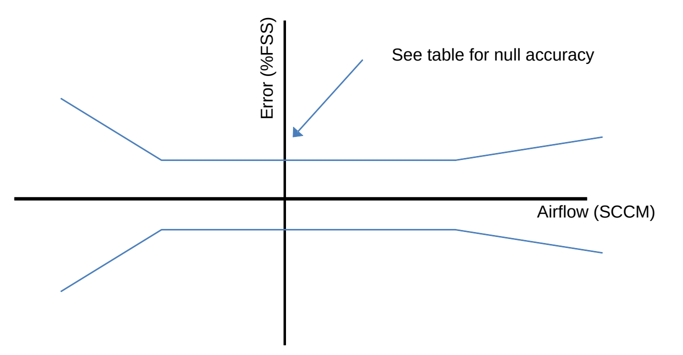
Table 2: Operating Characteristics

Characteristic	Parameter	Note
Supply voltage	3.3 Vdc ±10%; 5.0 Vdc ±10%	–
Supply current	16 mA max.	–
Power: 3.3 Vdc 5.0 Vdc	 23 mW typ. 38 mW typ.	–
Operating temperature range	-20 °C to 70 °C [-4 °F to 158 °F]	–
Compensated temperature range	0 °C to 50 °C [32 °F to 122 °F]	1
Accuracy	*See Figure 1*	2, 4
Total error band (TEB)	*See Figure 2*	3, 4
Null accuracy	±0.02% FSS	4, 10
Response time	1 ms typ.	5
Resolution	12 bit min.	–
Start up time	17 ms	6
Warm up time	30 ms	7
Calibration media	gaseous nitrogen	8
Bus standards	I^2C, fast mode (up to 400 kHz)	9
Null stability	±0.01% FSS maximum deviation from null output after 1000 hours at 25 °C	–
Reverse polarity protection	no	–

Notes:
1. Custom and extended compensated temperature ranges are possible. Contact Honeywell for details.
2. Accuracy is the maximum deviation from the nominal digital output over the compensated flow range at a reference temperature of 25 °C. Errors include offset, span, non-linearity, hysteresis and non-repeatability (see Figure 1 for the Accuracy Error Band vs Flow).
3. Total error band includes all errors over the compensated flow range including all effects due to temperature over the compensated temperature range (see Figure 2 for the Total Error Band).
4. Full Scale Span (FSS) is the algebraic difference between the digital output at the forward Full Scale (FS) flow and the digital output at the reverse FS flow. Forward flow is defined as flow from P1 to P2 as shown in Figure 8. The references to mass flow (SCCM) refer to gas flows at the standard conditions of 0 °C and atmospheric pressure 760 (101.3 kPa).
5. Response time: time to electrically respond to any mass flow change at the microbridge airflow transducer (response time of the transducer may be affected by the pneumatic interface).
6. Start-up time: time to first valid reading of serial number proceeding streaming 14-bit flow measurements.
7. Warm-up time: time to the first valid flow measurement after power is applied.
8. Default calibration media is dry nitrogen gas. Please contact Honeywell for other calibration options.
9. Refer to the Technical Note "I^2C Communications with Honeywell Digital Airflow Sensors" for I^2C protocol information.
10. Null accuracy is the maximum deviation in output at 0 SCCM from the ideal transfer function over the compensated temperature range. This includes offset errors, thermal airflow hysteresis and repeatability errors.

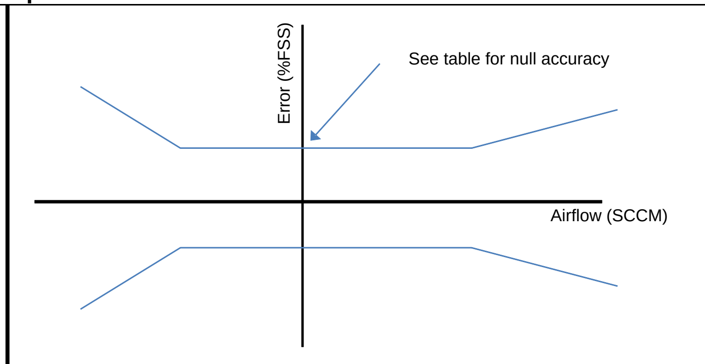
±50 SCCM to ±750 SCCM

Figure 1. Accuracy Error Band for Bidirectional Forward Flow Optimized



Sensor Range	Applied Flow (SCCM)	Accuracy Error (%FSS)
±50 SCCM	-50 to -16.7	±0.06 x flow (±6% reading)
	-16.7 to 0	±1
	0	±0.08
	0 to 20	±1
	20 to 50	±0.05 x flow (±5% reading)
±100 SCCM	-100 to -14.3	±0.035 x flow (±7% reading)
	-14.3 to 0	±0.5
	0	±0.04
	0 to 20	±0.5
	20 to 100	±0.025 x flow (±5% reading)
±200 SCCM	-200 to -11.1	±0.0225 x flow (±9% reading)
	-11.1 to 0	±0.25
	0	±0.02
	0 to 40	±0.25
	40 to 200	±0.006 x flow (±2.5% reading)
±400 SCCM	-400 to -26.7	±0.0112 x flow (±9% reading)
	-26.7 to 0	±0.3
	0	±0.02
	0 to 68.6	±0.3
	68.6 to 400	±0.0044 x flow (±3.5% reading)
±750 SCCM	-750 to -31.3	±0.008 x flow (±12% reading)
	-31.3 to 0	±0.25
	0	±0.02
	0 to 68.2	±0.25
	68.2 to 750	±0.0036 x flow (±5.5% reading)

Figure 2. Total Error Band for Bidirectional Forward Flow Optimized



Sensor Range	Applied Flow (SCCM)	Total Error Band (%FSS)
±50 SCCM	-50 to -14.3	±0.07 x flow (±7% reading)
	-14.3 to 0	±1
	0	±0.08
	0 to 14.3	±1
	14.3 to 50	±0.07 x flow (±7% reading)
±100 SCCM	-100 to -14.3	±0.035 x flow (±7% reading)
	-14.3 to 0	±0.5
	0	±0.04
	0 to 16.7	±0.5
	16.7 to 100	±0.03 x flow (±6% reading)
±200 SCCM	-200 to -11.1	±0.0225 x flow (±9% reading)
	-11.1 to 0	±0.25
	0	±0.02
	0 to 22.2	±0.25
	22.2 to 200	±0.01125 x flow (±4.5% reading)
±400 SCCM	-400 to -32	±0.0125 x flow (±10% reading)
	-32 to 0	±0.4
	0	±0.02
	0 to 71.1	±0.4
	71.1 to 400	±0.00625 x flow (±4.5% reading)
±750 SCCM	-750 to -31.25	±0.008 x flow (±12% reading)
	-31.25 to 0	±0.25
	0	±0.02
	0 to 50	±0.25
	50 to 750	±0.005 x flow (±7.5% reading)

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Table 3. Environmental Characteristics

Characteristic	Parameter
Humidity	0% to 95% RH, non-condensing
Shock	100 g, 11 ms
Vibration	15 g at 20 Hz to 2000 Hz
ESD	Class 3B per MIL-STD 883G
Radiated immunity	Level 3 from (80 MHz to 1000 MHz) per spec IEC61000-4-3

Table 4. Wetted Materials

Characteristic	Parameter
Covers	high temperature polymer
Substrate	PCB
Adhesives	epoxy
Electronic components	silicon, gold
Compliance	RoHS, WEEE

Table 5. Recommended Mounting and Implementation

Characteristic	Parameter
Mounting screw size	5-40
Mounting screw torque	0.68 N m [6 in-lb]
Tubing for long port style	70 durometer, size 0.125 inch inside diameter, 0.250 inch outside diameter silicone tubing
O-ring for short port style	AS568A, Size 7, Silicone, Shore A 70
O-ring for long port style	AS568A, Size 10, Silicone, Shore A 70
Filter recommendation	5-micron filter upstream of the sensor

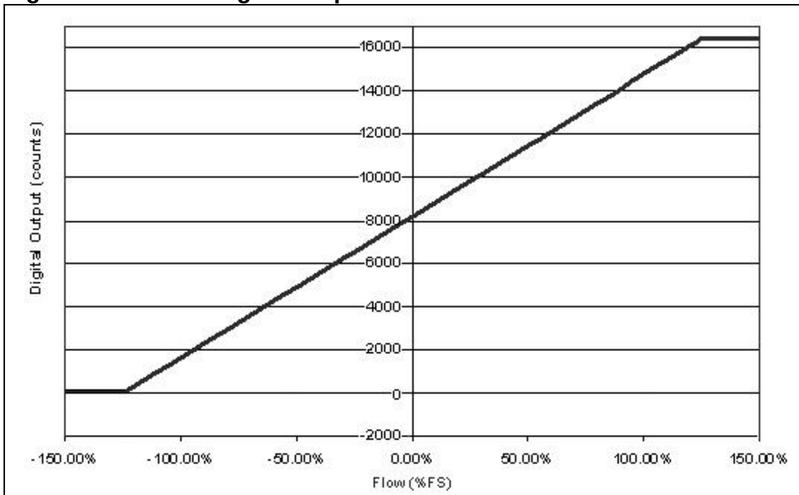
CAUTION

LARGE PARTICULATE DAMAGE

Use a 5-micron filter upstream of the sensor to keep media flow through the sensor free of condensing moisture and particulates. Large, high-velocity particles or conductive particles may damage the sensing element.

Failure to comply with these instructions may result in product damage.

Figure 3. Nominal Digital Output



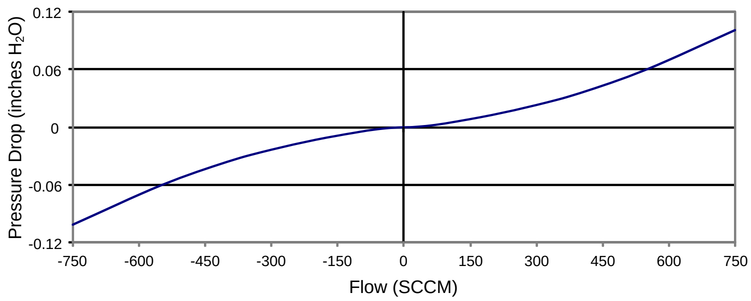
Ideal Transfer Function

Digital Output Code = 16384 * [0.5 + 0.4 * (Flow Applied/Full Scale Flow)]

Flow Applied = Full Scale Flow * [(Digital Output Code/16384) - 0.5]/0.4

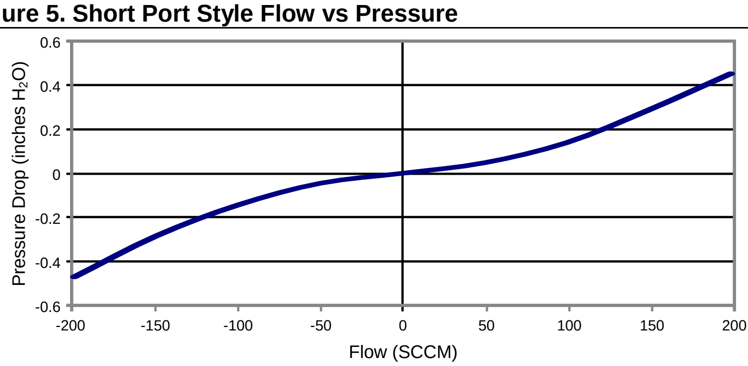
±50 SCCM to ±750 SCCM

Figure 4. Long Port Style Flow vs Pressure



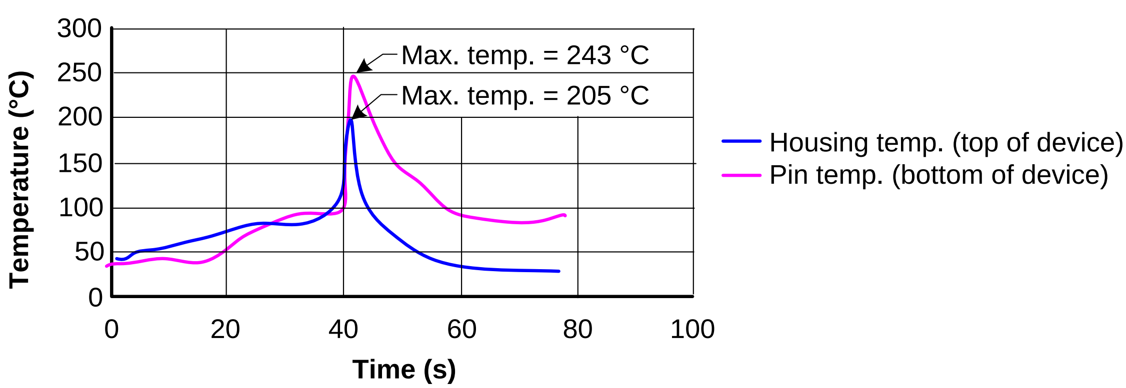
Flow (SCCM)	Typ. Pressure Drop for Long Port	
	inH_2O	mbar
-750	-0.1011	-0.2517
-550	-0.0602	-0.1499
-400	-0.0358	-0.0891
-300	-0.0232	-0.0578
-200	-0.0129	-0.0321
-100	-0.0046	-0.0114
-50	-0.0014	-0.0035
-20	-0.0003	-0.0007
0	0.0000	0.0000
20	0.0003	0.0007
50	0.0014	0.0035
100	0.0046	0.0014
200	0.0129	0.0321
300	0.0232	0.0578
400	0.0358	0.0891
550	0.0602	0.1499
750	0.1011	0.2517

Figure 5. Short Port Style Flow vs Pressure



Flow (SCCM)	Typ. Pressure Drop for Short Port	
	inH_2O	mbar
-200	-0.470	-1.1707
-150	-0.284	-0.7074
-100	-0.143	-0.3562
-50	-0.045	-0.1120
0	0.000	0.0000
50	0.048	0.1196
100	0.139	0.3462
150	0.287	0.7149
200	0.452	1.2589

Figure 6. Wave Solder Profile



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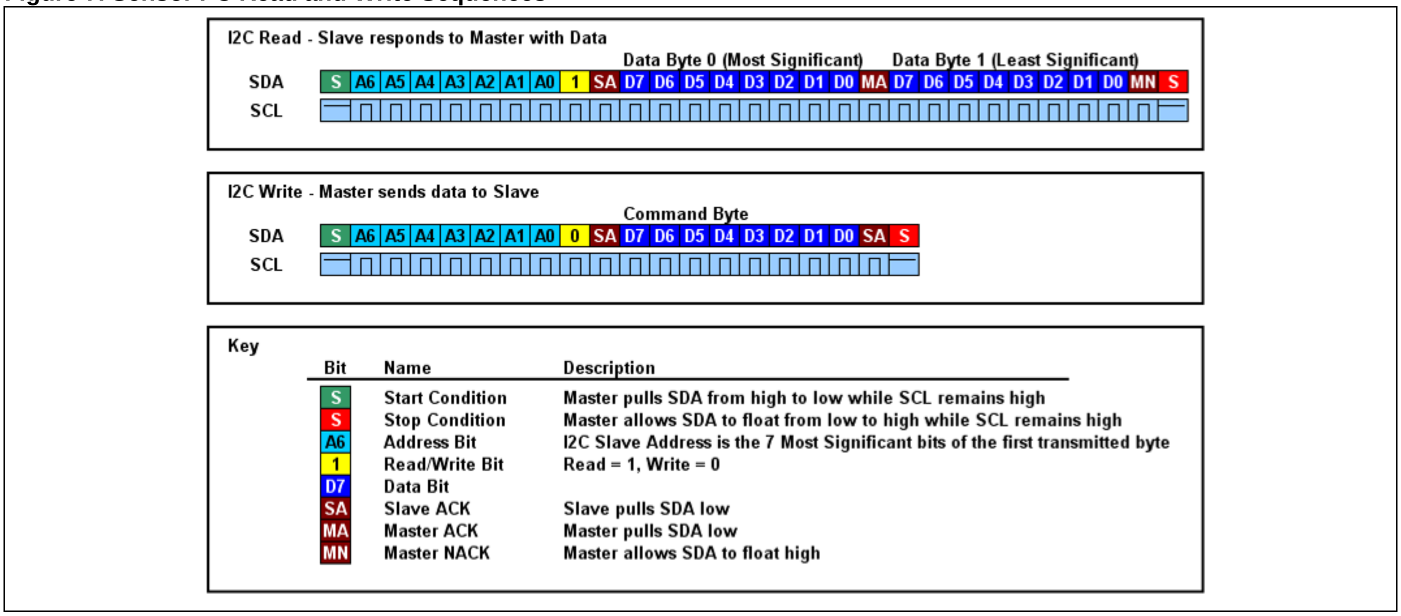
Digital Interface

For additional details on the use of Zephyr with digital output see the Technical Note “I²C Communications with Honeywell Digital Airflow Sensors”.

The sensor uses the I^2C standard for digital communication with a slave address specified in the Nomenclature and Order Guide in Figure 8. Following sensor power-up, each of the first two read sequences shown in Figure 7 will respond with 2 bytes of the unique 4-byte Serial Number. The first read after power-up will respond with the two most significant bytes of the Serial Number, while the second read will respond with the two least significant bytes of the Serial Number. For reliable performance, allow sensor to be powered for the sensor startup time before performing the first read, then allow a 10 ms command response time before performing the second read.

Figure 7. Sensor I^2C Read and Write Sequences



After the power-up read sequence described above, the sensor will respond to each I^2C read request with a 16-bit (2 byte) digital flow reading. Read requests taken faster than the Response Time (1 ms) are not guaranteed to return fresh data. The first two bits of each flow reading will be ‘00’, while non-flow responses (such as error and status codes) will begin with ‘11’.

The maximum sink current on SCL or SDA is 2 mA. Therefore, if the pull-up resistors are biased by V_{DD} and if V_{DD} reaches the maximum supply voltage of 6 V, then the pull-up resistors for SCL and SDA must be greater than 3.0 kΩ to limit the sink current to 2 mA. The typical value for SCL and SDA pull-up resistors is 4.7 kΩ (this value depends on the bus capacitance and the bus speed).

Figure 8. Nomenclature and Order Guide

For example, a **HAFBLF0200C4AX5** part number defines a Honeywell Zephyr™ Digital Airflow Sensor, bidirectional forward flow optimized, long port, fastener mount, 200 SCCM, I²C output with address 0x49, 10% to 90% transfer function, 5.0 Vdc supply voltage.

HAF	B	L	F	0200	C	4	A	X	5
Product Series	Flow Direction	Port Style	Housing Style	Flow Range[2]	Unit	Output Format	Transfer Function	Reserved for Future Use	Supply Voltage
HAF Series High Accuracy Airflow Sensor	**B** Bidirectional forward flow optimized	**L** Long port[1]	**F** Fastener mount	**0050** 50 long port style only	**C** SCCM	**4** Digital I²C address: 0x49	**A** 10% to 90% of Full Scale Output (FSO)	**X** XXXXX	**3** 3.3 Vdc
	S Bidirectional symmetric	**S** Short port	**S** Snap mount[1]	**0100** 100 long port style only		**5** Digital I²C address: 0x59			**5** 5.0 Vdc
				0200 200 long or short port		**6** Digital I²C address: 0x69			
				0400 400 long port style only		**7** Digital I²C address: 0x79			
				0750 750 long port style only					

Notes:

1. The Long Port **Port Style** with the Snap Mount **Housing Style** is not a valid configuration.
2. The 200 SCCM **Flow Range** is available in the long and short **Port Styles**.

Customer-specific Requirements

Apart from the general configuration required, other customer-specific requirements are also possible. Please contact Honeywell.

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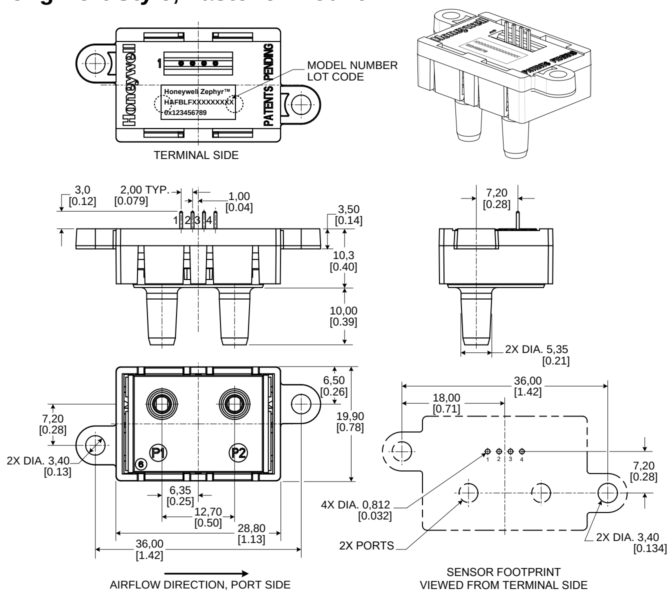
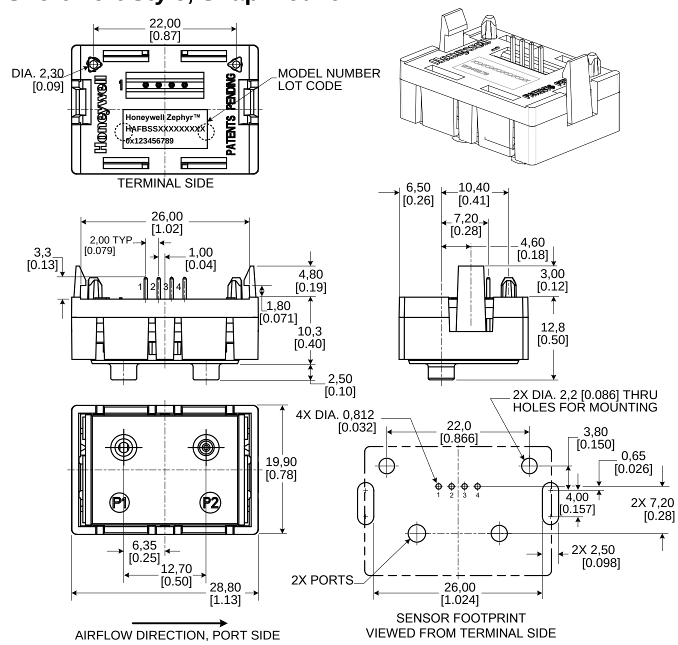
Figure 9. Mounting Dimensions (For reference only: mm [in]). Additional port and housing styles available.

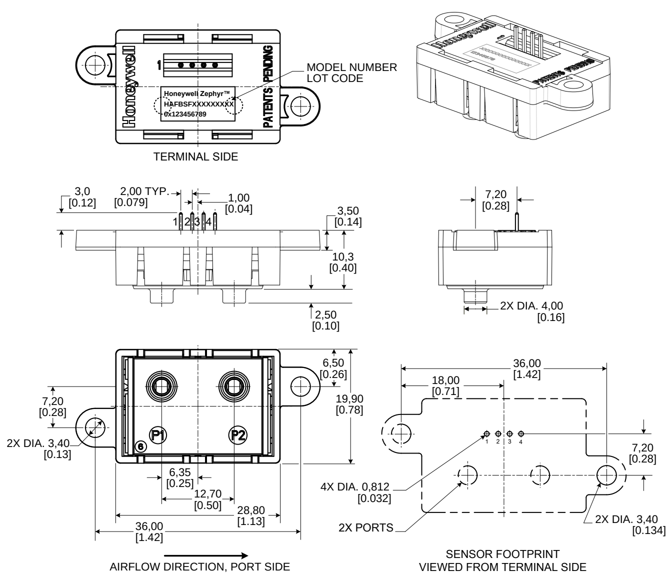
Long Port Style, Fastener Mount



Short Port Style, Snap Mount



Short Port Style, Fastener Mount



Pinout (digital function)

1 = SCL
2 = Vsupply
3 = ground
4 = SDA

⚠ WARNING

PERSONAL INJURY

DO NOT USE these products as safety or emergency stop devices or in any other application where failure of the product could result in personal injury.

Failure to comply with these instructions could result in death or serious injury.

WARRANTY/REMEDY

Honeywell warrants goods of its manufacture as being free of defective materials and faulty workmanship. Honeywell's standard product warranty applies unless agreed to otherwise by Honeywell in writing; please refer to your order acknowledgement or consult your local sales office for specific warranty details. If warranted goods are returned to Honeywell during the period of coverage, Honeywell will repair or replace, at its option, without charge those items it finds defective. **The foregoing is buyer's sole remedy and is in lieu of all other warranties, expressed or implied, including those of merchantability and fitness for a particular purpose. In no event shall Honeywell be liable for consequential, special, or indirect damages.**

While we provide application assistance personally, through our literature and the Honeywell web site, it is up to the customer to determine the suitability of the product in the application.

Specifications may change without notice. The information we supply is believed to be accurate and reliable as of this printing. However, we assume no responsibility for its use.

⚠ WARNING

MISUSE OF DOCUMENTATION

- The information presented in this product sheet is for reference only. Do not use this document as a product installation guide.
- Complete installation, operation, and maintenance information is provided in the instructions supplied with each product.

Failure to comply with these instructions could result in death or serious injury.

SALES AND SERVICE

Honeywell serves its customers through a worldwide network of sales offices, representatives and distributors. For application assistance, current specifications, pricing or name of the nearest Authorized Distributor, contact your local sales office or:

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