



# Honeywell Zephyr™ Digital Airflow Sensors:

## **HAF Series—High Accuracy**

10 SLPM, 15 SLPM, 20 SLPM, 50 SLPM, 100 SLPM,  
200 SLPM or 300 SLPM



# Honeywell Zephyr™ Digital Airflow Sensors

## HAF Series - High Accuracy

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 10 SLPM, 15 SLPM, 20 SLPM, 50 SLPM, 100 SLPM, 200 SLPM or 300 SLPM, with custom flow ranges available. The sensors are fully calibrated and temperature compensated with an onboard Application Specific Integrated Circuit (ASIC).

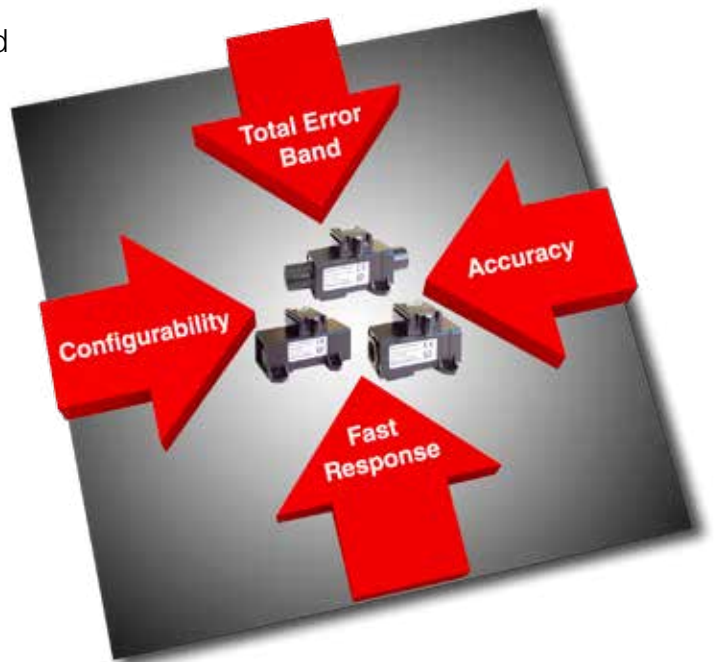
The HAF Series >10 SLPM is compensated over the calibrated temperature range of 0 °C to 50 °C [32 °F to 122 °F]. The state-of-the-art ASIC-based compensation provides digital (I<sup>2</sup>C) outputs with a response time of 1 ms.

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.

### *What makes our sensors better?*

- **Precise measurement:** The industry's smallest Total Error Band, fast response time, and high accuracy provide precise measurement and high performance in the customer's application
- **Saves time:** Configurable and customizable with a choice of port styles simplifies design and reduces production time
- **Cost-effective:** Reduces printed circuit board (PCB) size and overall design and production costs



TIGHT TOTAL ERROR BAND • HIGH ACCURACY • FAST RESPONSE

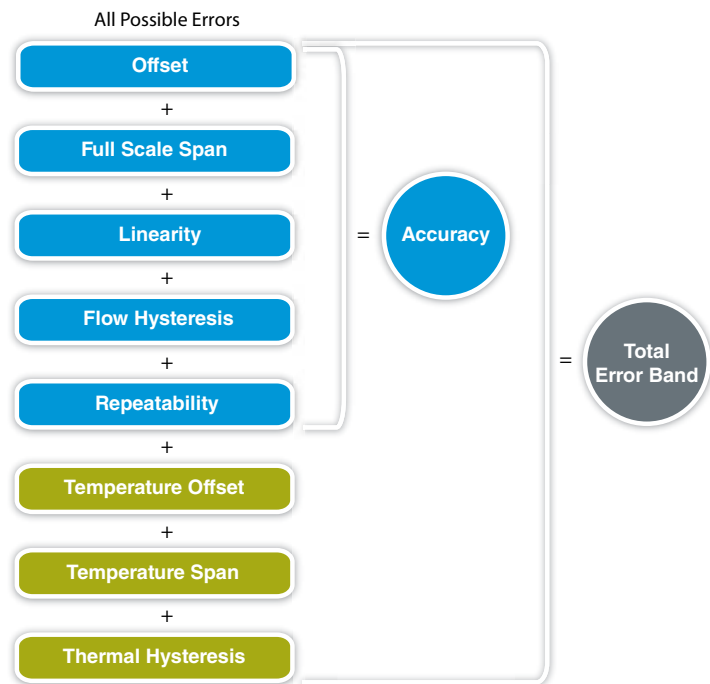
# Features and Benefits

**Precise measurement maximizes performance.**

## TOTAL ERROR BAND (TEB)\*

Honeywell specifies TEB, the most comprehensive, clear, and meaningful measurement that provides the sensor's true accuracy (see Figure 1). TEB allows for precise airflow measurement, often ideal for demanding applications with high accuracy requirements for precise airflow measurement.

- 10 SLPM, 15 SLPM, 20 SLPM, 50 SLPM, 100 SLPM, 200 SLPM:
  - 0 %FS to 12.5 %FS = 0.5% FS
  - 12.5 %FS to 100 %FS = 4.0% reading
- 300 SLPM only:
  - 0 SLPM to 199 SLPM = 0.5% FS or 4.0% reading
  - 200 SLPM to 300 SLPM = 7.0% reading



**Figure 1. Total Error Band vs. Accuracy**

Other airflow sensor manufacturers only report on accuracy, while Honeywell reports Total Error Band.

## HIGH ACCURACY

Ideal for use in demanding applications that require high accuracy.

- 10 SLPM, 15 SLPM, 20 SLPM, 50 SLPM, 100 SLPM, 200 SLPM:
  - 0 %FS to 14.3 %FS = 0.5% FS
  - 14.3 %FS to 100 %FS = 3.5% reading
- 300 SLPM only:
  - 0 %FS to 14.3 %FS = 0.5% FS
  - 14.6 %FS to 100 %FS = 3.5% reading

# Features and Benefits

## **FAST RESPONSE TIME (1 MS)**

Allows the customer's application to respond quickly to a change in airflow, important in critical medical (e.g., anesthesia) and industrial (e.g., fume hood) applications.

## **HIGH STABILITY**

Reduces errors due to thermal effects and null shift, providing accurate readings over time and often eliminating the need for system calibration after PCB mount and periodically over time.

## **HIGH SENSITIVITY AT VERY LOW FLOWS**

Provides a fast response time at the onset or cessation of flow.

## **HIGH 12-BIT RESOLUTION**

Increases the ability to sense small airflow changes, allowing customers to more precisely control their application.

***Simplifies design and integration while reducing costs.***

## **WIDE AIRFLOW RANGE\***

The industry's broadest airflow range measures mass flow with standard flow ranges of 0-10 SLPM, 0-15 SLPM, 0-20 SLPM, 0-50 SLPM, 0-100 SLPM, 0-200 SLPM, and 0-300 SLPM, or custom flow ranges, increasing the options to integrate the sensor into the application.

## **CHOICE OF PORT STYLES\***

Manifold mount, 22 mm OD tapered male fitting, and G 3/8 female threaded fitting provide flexibility to choose the pneumatic connection that is best for the customer's application.

## **LINEAR OUTPUT\***

Provides a more intuitive sensor signal than the raw output of basic airflow sensors, which can help reduce production costs, design, and implementation time.

## **WIDE SUPPLY VOLTAGE RANGE [3 VDC TO 10 VDC]**

Flexible regulated power circuit allows the designer the flexibility to choose the supply voltage that works best in the system.

## **ASIC-BASED I<sup>2</sup>C DIGITAL OUTPUT**

Simplifies integration to microprocessors or microcontrollers, reducing PCB complexity and component count.

## **FACTORY OR CUSTOM CALIBRATION FOR MULTIPLE GAS TYPES**

Can be factory calibrated for gas types such as dry air, helium (He), argon (Ar), nitrogen (N<sub>2</sub>), nitrous oxide (N<sub>2</sub>O), and carbon dioxide (CO<sub>2</sub>), or custom calibrated for the end customer, eliminating the need to implement gas correction factors.

## **ROHS-COMPLIANT MATERIALS**

Meet Directive 2002/95/EC.

# Potential Applications



## MEDICAL

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**ANESTHESIA DELIVERY MACHINES**

**VENTILATORS**

**VENTRICULAR ASSIST DEVICES (HEART PUMPS)**

**SPIROMETERS**

**LAPAROSCOPY**

## INDUSTRIAL

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**ANALYTIC INSTRUMENTATION (SPECTOMETRY, CHROMATOGRAPHY)**

**AIR-TO-FUEL RATIO**

**FUEL CELLS**

**FUME HOODS**

**GAS LEAK DETECTION**

**PROCESS CONTROL GAS MONITORING**

**VACUUM PUMP MONITORING**



# Honeywell Zephyr™ Digital Aiflow Sensors

## HAF Series—High Accuracy

Table 1. Absolute Maximum Ratings<sup>1</sup>

Characteristic	Parameter
Supply voltage	-0.3 Vdc to 11.0 Vdc
Voltage on digital I/O output pins	-0.3 Vdc to 3.0 Vdc <sup>2</sup>
Storage temperature range	-40 °C to 100 °C [-40 °F to 212 °F]
Maximum flow change	10,000 SLPM/s
Maximum common mode pressure	60 psi at 25 °C [77 °F]
Maximum flow	350 SLPM

<sup>1</sup>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.

<sup>2</sup>Digital I/O pins are diode protected at this voltage up to 2 mA. Digital bus voltage may exceed this value if the maximum digital bus current is limited to 2 mA or less. The maximum bus current is generally determined by the bus pull-up resistors

### CAUTION

#### IMPROPER USE

Do not use these products to sense liquid flow

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

### CAUTION

#### PRODUCT DAMAGE

Do not disassemble these products.

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

Table 2. Operating Specifications

Characteristic	Parameter
Supply voltage	3 Vdc to 10 Vdc
Supply current	20 mA max.
Power:	
3 Vdc	60 mW max.
10 Vdc	200 mW max.
Calibrated temperature range <sup>1</sup>	0 °C to 50 °C [32 °F to 122 °F]
Operating temperature range	-20 °C to 70 °C [-4 °F to 158 °F]
Full scale (FS) flow <sup>2</sup>	10 SLPM, 15 SLPM, 20 SLPM, 50 SLPM, 100 SLPM, 200 SLPM, 300 SLPM
Calibrated flow range	0 to 10 SLPM, 0 to 15 SLPM, 0 to 20 SLPM, 0 to 50 SLPM, 0 to 100 SLPM, 0 to 200 SLPM, 0 to 300 SLPM
Calibration gas <sup>3</sup>	clean, dry air
Accuracy <sup>4</sup>	
0 SLPM, 15 SLPM, 20 SLPM, 50 SLPM, 100 SLPM, 200 SLPM:	
0 %FS to 14.3 %FS	0.5% FS
14.3 %FS to 100 %FS	3.5% reading
300 SLPM only:	
0 %FS to 14.3 %FS (0 SLPM to 43 SLPM)	0.5% FS
14.6 %FS to 100 %FS (44 SLPM to 300 SLPM)	3.5% reading

# 10 SLPM, 15 SLPM, 20 SLPM, 50 SLPM, 100 SLPM, 200 SLPM or 300 SLPM

**Table 3. Operating Specifications (continued)**

Characteristic	Parameter
Total Error Band: <sup>5</sup> 0 SLPM, 15 SLPM, 20 SLPM, 50 SLPM, 100 SLPM, 200 SLPM: 0 %FS to 12.5 %FS 12.5 %FS to 100 %FS 300 SLPM only: 0 %FS to 14.3 %FS (0 SLPM to 43 SLPM) 14.6 %FS to 66.3 %FS (44 SLPM to 199 SLPM) 66.6 %FS to 100 %FS (200 SLPM to 300 SLPM)	0.5% FS 4.0% reading 0.5% FS 4.0% reading 7.0% reading
Null accuracy <sup>6</sup>	±0.5 %FS
Flow response time <sup>7</sup>	1 ms
Warm up time <sup>8</sup>	35 ms
Resolution: 10 SLPM 15 SLPM 20 SLPM 50 SLPM 100 SLPM 200 SLPM 300 SLPM	0.002 SLPM 0.003 SLPM 0.003 SLPM 0.008 SLPM 0.015 SLPM 0.020 SLPM 0.030 SLPM
Bus standards <sup>9</sup>	I <sup>2</sup> C fast mode (up to 400 kHz)
Proof pressure	150 psig
Burst Pressure	200 psig
Reverse polarity protection	no

<sup>1</sup>Custom and extended temperature compensated ranges are possible. Contact Honeywell for details.

<sup>2</sup>Honeywell standard for mass flow rate units is SLPM, which has reference conditions of 0 °C and 1 atm. Custom units are given as LPM with listed reference conditions at the first mention.

<sup>3</sup>Contact Honeywell for requirements with other custom gases for calibration. See the Technical Note “Gas Media Compatibility and Correction Factors”.

<sup>4</sup>Accuracy is the maximum deviation in output from nominal over the entire calibrated flow range at 25 °C. Errors include Offset, Full Scale Span, Linearity, Flow Hysteresis, and Repeatability. (See Figures 1 and 5.)

<sup>5</sup>Total Error Band (TEB) is the maximum deviation in output from nominal over the entire calibrated flow range and temperature range. Total Error Band includes all Accuracy errors, as well as all temperature effects over the compensated temperature range, including Temperature Offset, Temperature Span and Thermal Hysteresis. (See Figures 1 and 5.)

<sup>6</sup>Null Accuracy is the maximum deviation in output from nominal at null flow over the entire calibrated temperature range.

<sup>7</sup>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).

<sup>8</sup>Warm-up time: time to the first valid flow measurement after power is applied.

<sup>9</sup>Refer to the Technical Note “I<sup>2</sup>C Communications with Honeywell Digital Airflow Sensors” for I<sup>2</sup>C protocol information.

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**Table 4. Compatible Gases**

Gas	Calibration Type
Dry air	standard
Helium (He)	optimized calibration available
Argon (Ar)	
Nitrogen (N <sub>2</sub> )	
Nitrous oxide (N <sub>2</sub> O)	
Carbon dioxide (CO <sub>2</sub> )	
Oxygen (O <sub>2</sub> )	See the Technical Note “Gas Media Compatibility and Correction Factors”.
80/20 He/O <sub>2</sub> Mix	
Methane (CH <sub>4</sub> )	
Xenon (Xe)	

**Table 5. Environmental Specifications**

Characteristic	Parameter
Humidity	0% to 95% RH, non-condensing
Shock	30 g, 6 ms
Vibration	1.33 g at 10 Hz to 500 Hz
ESD	ESD IEC6100-4-2 air discharge up to 8 kV, or direct contact discharge up to 4 kV
Radiated immunity: test conditions for ≥20 SLPM test conditions for ≤20 SLPM	Level 3 from 80 MHz to 1000 MHz per IEC61000-4-3 1 meter shielded cable with 3 cm exposed leads at connector 1 meter shielded cable with 3 cm exposed leads at connector and 280 Ohm at 1 MHz ferrite bead

**Table 6. Materials Specifications**

Characteristic	Parameter
Wetted materials	glass reinforced (GR) thermoplastic polymer, gold, silicon, silicon dioxide, silicon nitride, epoxy, PCB epoxy composite
Housing	GR thermoplastic polymer
Substrate	PCB
Adhesives	epoxy
Electronic components	silicon, gold
Compliance	RoHS, WEEE



# 10 SLPM, 15 SLPM, 20 SLPM, 50 SLPM, 100 SLPM, 200 SLPM or 300 SLPM

Table 7. Recommended Mounting and Implementation

Characteristic	Parameter
Mounting screw size	10-32
Mounting screw torque	1,13 N m [20 in-lb]
Electrical connection	6 pin SIP connector
Pneumatic connection	manifold mount, 22 mm OD tapered male fitting, G 3/8 female threaded fitting

Figure 2. Nomenclature and Order Guide<sup>1</sup>

For example, a **HAFUHM0020L4AXT** part number defines a Honeywell Zephyr™ Airflow Sensor, unidirectional flow, long port, manifold mount, 20 SLPM, I<sup>2</sup>C output with custom 0x49 address, 10% to 90% transfer function, 3 Vdc to 10 Vdc supply voltage.

HAF	U	HM	0020	L	4	A	X	T
Product Series	Flow Direction	Port Style	Flow Range	Unit	Output Format	Transfer Function	Reserved for Future Use	Supply Voltage
<b>HAF</b> Series high accuracy airflow sensor	<b>U</b> Unidirectional	<b>HM</b> Manifold mount	<b>0010</b> 10 <b>0015</b> 15 <b>0020</b> 20 <b>0050</b> 50 <b>0100</b> 100 <b>0200</b> 200 <b>0300</b> 300	<b>L</b> SLPM	<b>2</b> Digital I <sup>2</sup> C address: 0x29 <b>3</b> Digital I <sup>2</sup> C address: 0x39 <b>4</b> Digital I <sup>2</sup> C address: <b>0x49</b> <b>5</b> Digital I <sup>2</sup> C address: 0x59 <b>6</b> Digital I <sup>2</sup> C address: 0x69 <b>7</b> Digital I <sup>2</sup> C address: 0x79	<b>A</b> 10% to 90% of input	<b>X</b> XXXXX	<b>T</b> 3 Vdc to 10 Vdc

<sup>1</sup>Apart from the general configuration required, other customer-specific requirements are also possible. Please contact Honeywell.

Figure 3. All Available Standard Configurations



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Figure 4. Nominal Digital Output: 10 SLPM, 15 SLPM, 20 SLPM, 50 SLPM, 100 SLPM, 200 SLPM, or 300 SLPM

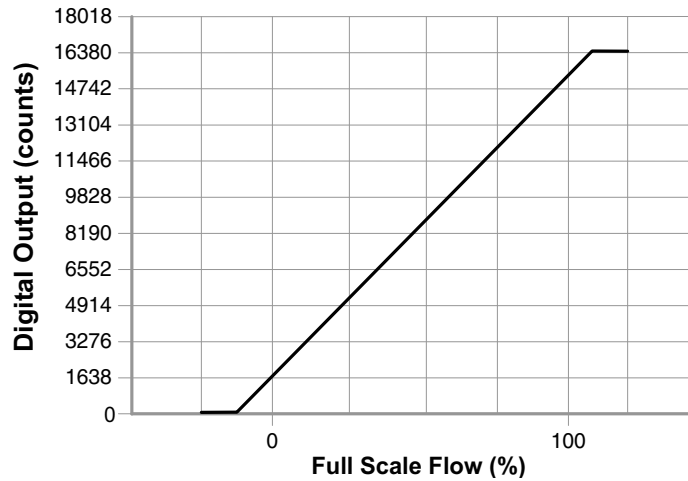
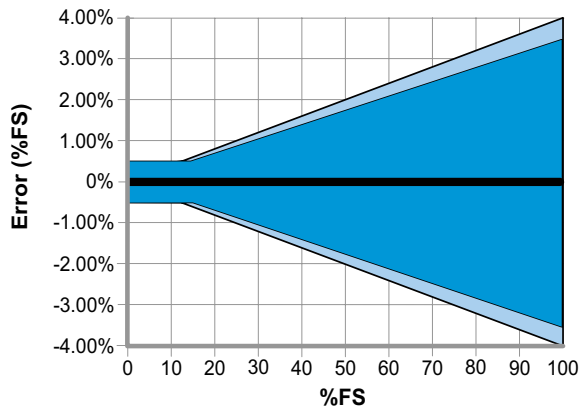


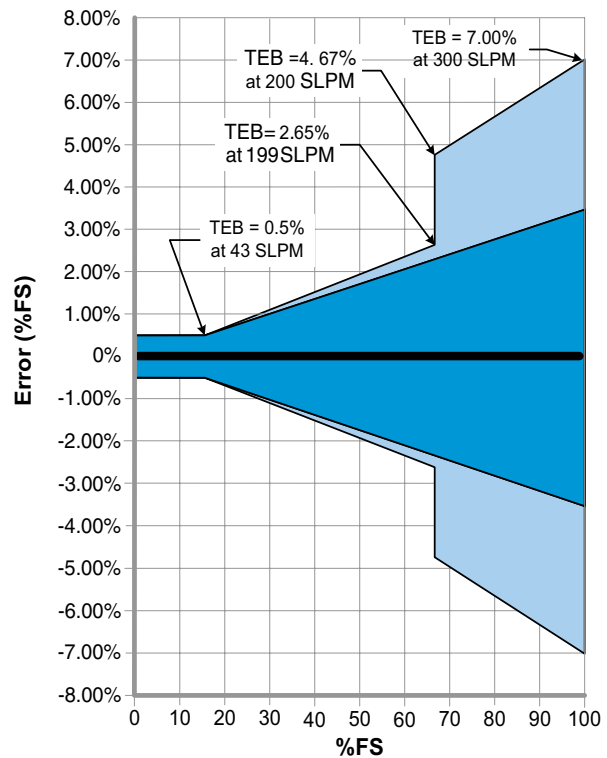
Figure 5. Accuracy and Total Error Band

10 SLPM, 15 SLPM, 20 SLPM, 50 SLPM, 100 SLPM, 200 SLPM



- Ideal**
- Accuracy**  
0 %FS to 14.3 %FS = 0.5%  
14.3 %FS to 100 %FS = 3.5%
- Total Error Band**  
0 %FS to 12.5 %FS = 0.5%

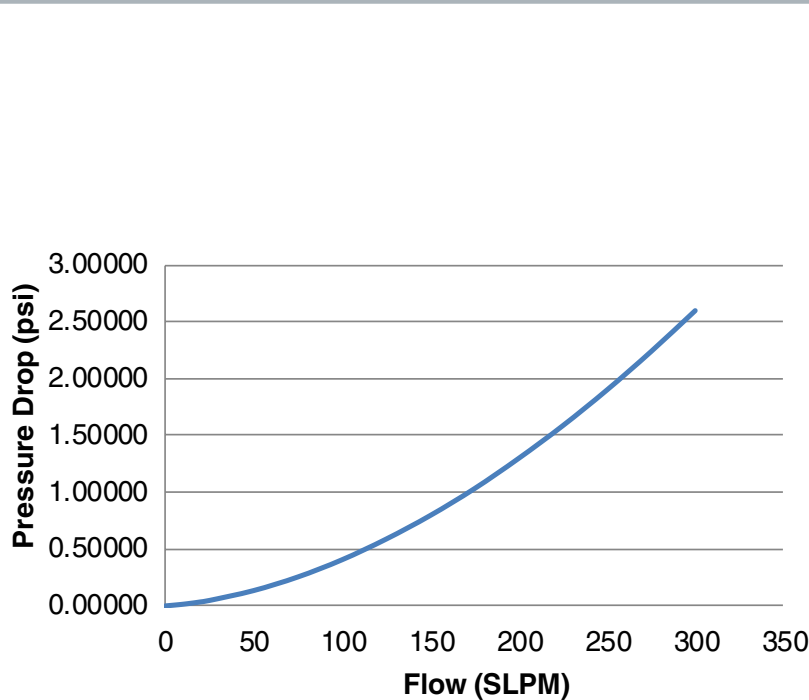
300 SLPM only



- Ideal**
- Accuracy**  
0 %FS to 14.3 %FS (0 SLPM to 43 SLPM) = 0.5%  
14.6 %FS to 100 %FS (44 SLPM to 300 SLPM) = 3.5%
- Total Error Band**  
0 %FS to 14.3 %FS (0 SLPM to 43 SLPM) = 0.5%  
14.6 %FS to 66.3 %FS (44 SLPM to 199 SLPM) = 4% reading  
66.6 %FS to 100 %FS (200 SLPM to 300 SLPM) = 7% reading

# 10 SLPM, 15 SLPM, 20 SLPM, 50 SLPM, 100 SLPM, 200 SLPM or 300 SLPM

Figure 6. Flow vs Pressure Drop: 10 SLPM, 15 SLPM, 20 SLPM, 50 SLPM, 100 SLPM, 200 SLPM, or 300 SLPM



Flow (SLPM)	Typical Pressure Drop		
	mbar	psi	inH <sub>2</sub> O
0	0	0.00000	0.04153338
1	0.1034586	0.00150	0.04153338
2	0.20582424	0.00298	0.04153338
4	0.39645192	0.00575	0.04153338
8	0.80254866	0.01163	0.04153338
10	1.02721818	0.01489	0.04153338
12	1.27909578	0.01854	0.04153338
14	1.54899066	0.02245	0.04153338
15	1.68593772	0.02443	0.04153338
16	1.82026278	0.02638	0.04153338
18	2.12584308	0.03081	0.04153338
20	2.44420632	0.03542	0.04153338
25	3.32048838	0.04812	0.04153338
50	9.3139443	0.13498	3.73907619
75	17.55251808	0.13498	7.046445664
100	27.97855332	0.13498	11.23196996
125	40.53260928	0.13498	16.27178662
150	54.8812269	0.79538	22.03202877
175	71.15758308	1.03127	28.5661601
200	89.5064674	1.29720	35.93230649
225	109.3632281	1.58497	43.90378866
250	131.0373825	1.89909	52.60486225
275	154.388940	2.23752	61.97932838
300	179.2351535	2.59761	71.95382248

Table 8. Ideal Transfer Function

Item	Equation
Digital Output Code	$16384 * [0.1 + 0.8 * (\text{Flow Applied}/\text{Full Scale Flow})]$
Flow Applied	$\text{Full Scale Flow} * [(\text{Digital Output Code}/16384) - 0.1]/0.8$

## Digital Interface

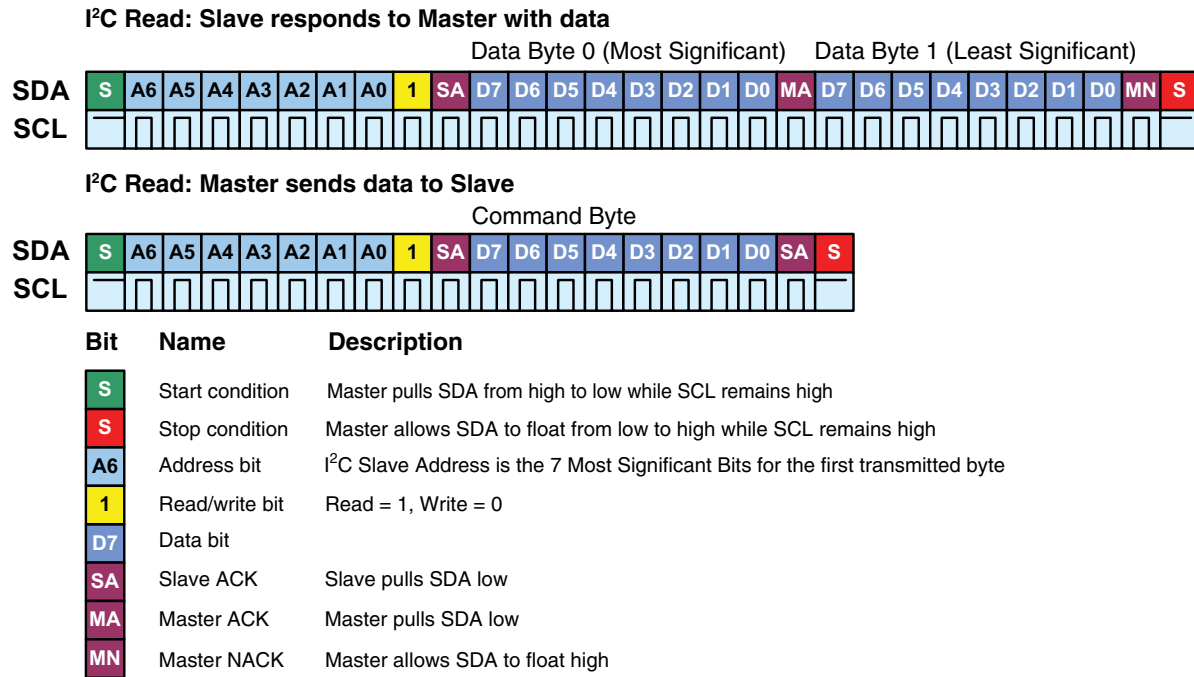
For additional details on the use of Zephyr with digital output see the Technical Note “I<sup>2</sup>C Communications with Honeywell Digital Airflow Sensors”.

The sensor uses the I<sup>2</sup>C standard for digital communication with a slave address specified in the Nomenclature and Order Guide in Figure 2. 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.

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Figure 7. Sensor I<sup>2</sup>C Read and Write Sequences



After the power-up read sequence described above, the sensor will respond to each I<sup>2</sup>C 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'. There are several user commands available as shown in Table 9. Following an I<sup>2</sup>C write sequence of a user command, the sensor will respond to the next I<sup>2</sup>C read request with a 16-bit response. Possible responses to user commands can be seen in Table 10.

Table 9. User Command Descriptions

Command Byte (Hexadecimal)	Command Name	Command Description	Command Response Time (Max.)
0x01	GetSerialNumber	Next two read requests will each return two bytes of the sensor's unique 4-byte Serial Number.	10 ms
0x02	PowerOnReset	Force Power-On reset of sensor microcontroller.	20 ms
0x03	Checksum	Calculates EEPROM Checksum and compares to production Checksum value. If the values match, the next read request will respond with 0xCCA5. Otherwise, the next read will respond with 0xCC90.	1 s

Table 10. Sensor Response Descriptions

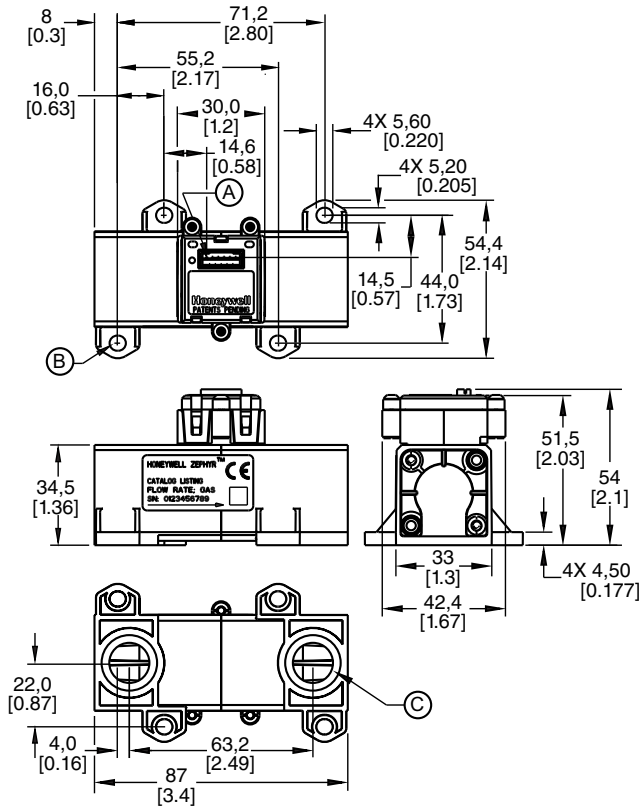
Sensor Response (Hexadecimal)	Response Name	Response Description
0xCCA5	POSACK	non-response command was executed successfully
0xCC99	BadCommand	command byte was not recognized
0xCC9A	BadParam	command sent with incorrect parameter bytes
0xCC9B	Failure	command failed during execution
0xCC90	BadChecksum	checksum did not match stored value
0xCCBB	Busy	sensor is busy calculating the checksum value

The maximum sink current on SCL or SDA is 2 mA. Therefore, if the pull-up resistors are biased by VDD, and if VDD 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).

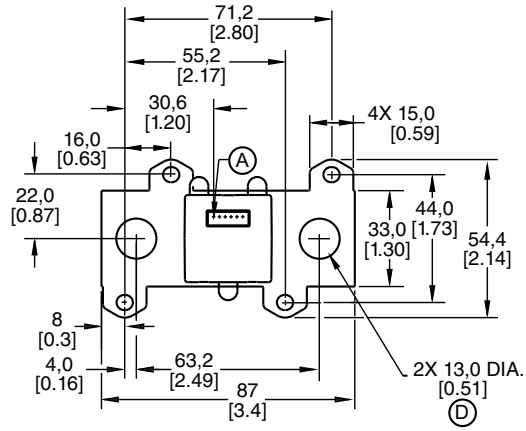
# 10 SLPM, 15 SLPM, 20 SLPM, 50 SLPM, 100 SLPM, 200 SLPM or 300 SLPM

Figure 8. Mounting Dimensions (For reference only: mm [in.])

## Port Style: Manifold Mount

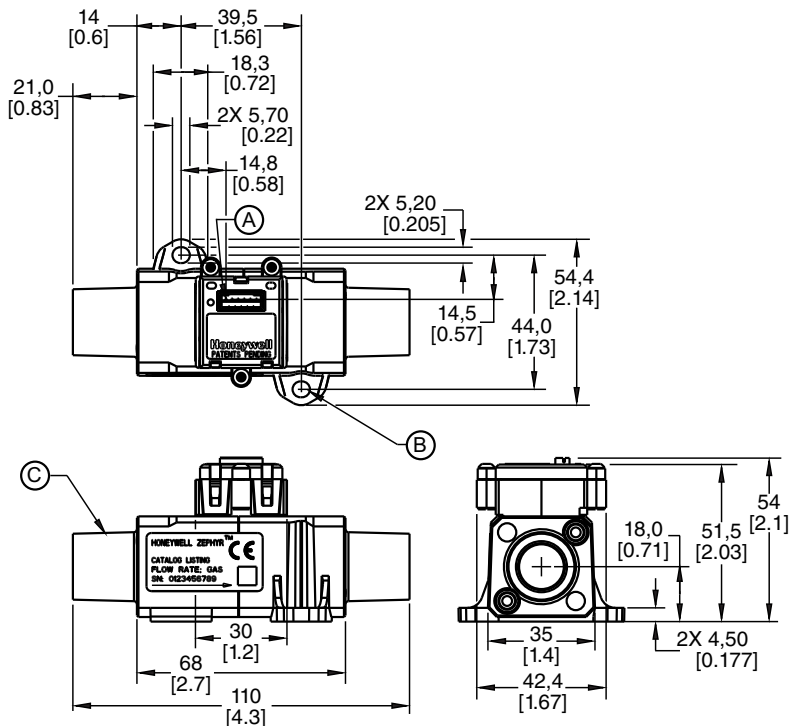


## Mounting Footprint

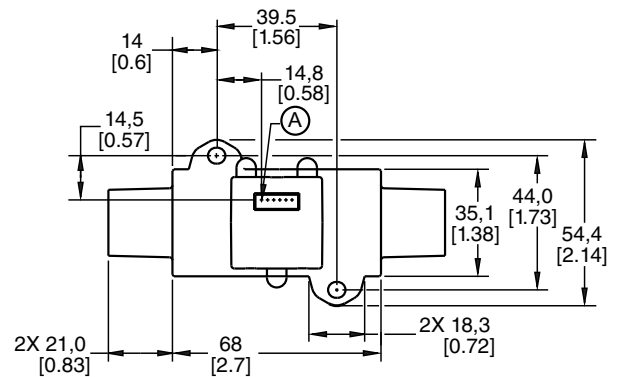


- (A) Pin 1.
- (B) 4X 10-32 pan head screws 1,13 N m [20 in-lb] torque.
- (C) 2X Gland for O-Ring AS568-113, 13,94 mm ID x 2,62 mm [0.549 in ID x 0.103 in W]. Two O-rings, AS568A-113 Durometer A65 to A80 Silicon or Viton, are required to seal sensor to manifold. O-rings are not included.
- (D) Flow channel.

## Port Style: 22 mm OD Tapered Male Fitting per ISO 5356



## Mounting Footprint



- (A) Pin 1.
- (B) 2X 10-32 pan head screws 1,13 N m [20 in-lb] torque.
- (C) 15 mm ID/22 mm OD tapered fitting per ISO 5356.

# Honeywell Zephyr™ Digital Aiflow Sensors

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Figure 8. Mounting Dimensions (For reference only: mm [in], continued.)

Port Style: G 3/8 Female Threaded Fitting per ISO 1179

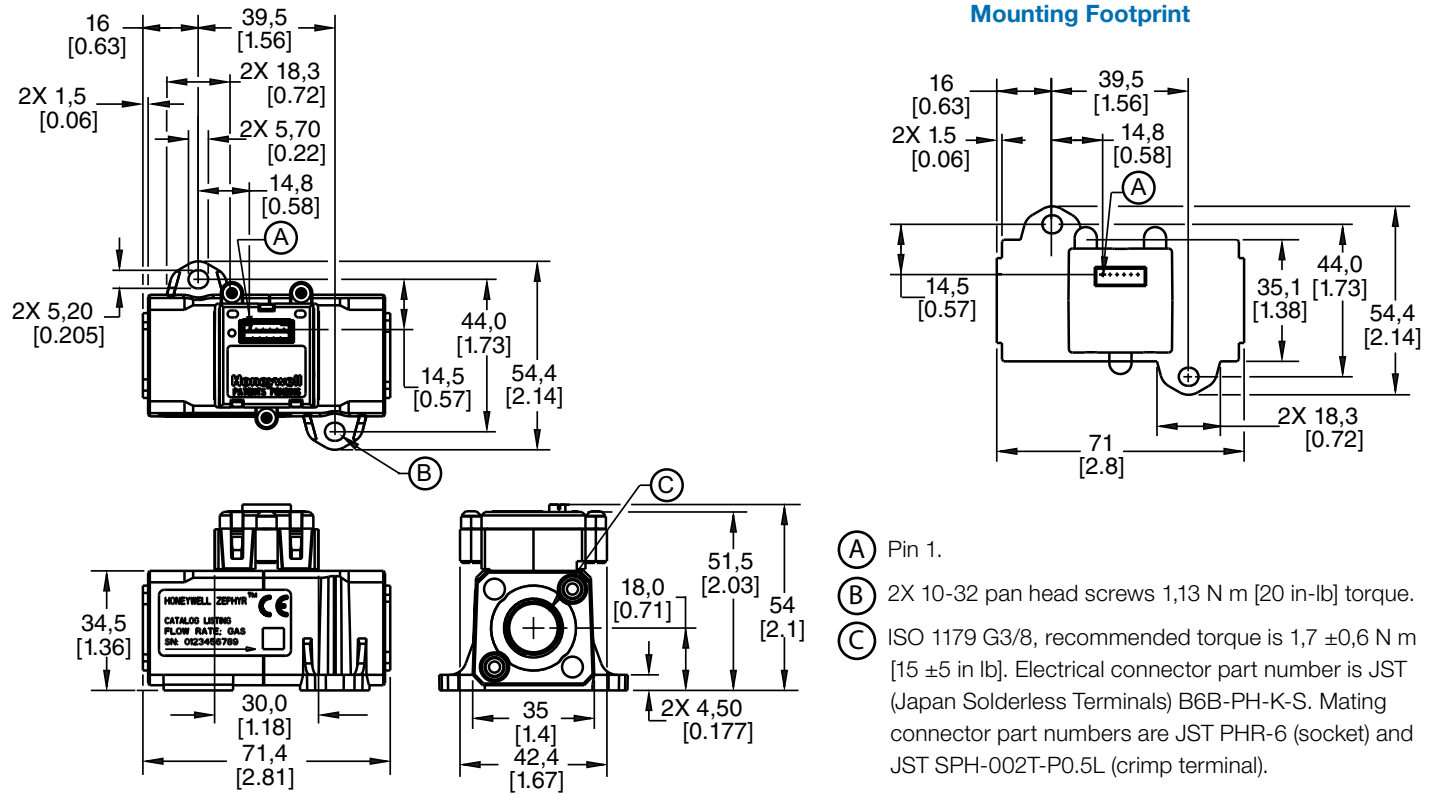


Table 11. Pinout (Digital Function)

Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6
NC	SCL	V <sub>DD</sub>	ground	SDA	NC

# 10 SLPM, 15 SLPM, 20 SLPM, 50 SLPM, 100 SLPM, 200 SLPM or 300 SLPM

## ADDITIONAL INFORMATION

The following associated literature is available at [sensing.honeywell.com](https://sensing.honeywell.com):

- Product line guide
- Product Part Listing/Nomenclature Tree
- Product Range Guide
- Technical Information
  - I<sup>2</sup>C Communications with Honeywell Digital Airflow Sensors
  - Gas Media Compatibility and Correction Factors
- Datasheet
- Application Specific Information

### **⚠ 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.**

### **⚠ 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.**

## 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 website, 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 issue; however, we assume no responsibility for its use.

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