

HAF SERIES

008268
Issue 6

Honeywell Zephyr™ Digital Airflow Sensors

High Accuracy: 10 SLPM, 15 SLPM, 20 SLPM, 50 SLPM, 100 SLPM, 200 SLPM, 300 SLPM

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 10 SLPM, 15 SLPM, 20 SLPM, 50 SLPM, 100 SLPM, 200 SLPM and 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 (I2C) 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

- 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.
- Wide airflow range: The industry's broadest airflow range measures mass flow with standard flow ranges of 0 to 10, 0 to 15, 0 to 20, 0 to 50, 0 to 100, 0 to 200 and 0 SLPM to 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) provides a flexible regulated power circuit which allows the designer the flexibility to choose the supply voltage that works best in the system.
- ASIC-based I2C digital output simplifies integration to microprocessors or microcontrollers, reducing PCB complexity and component count.
- RoHS-compliant materials Meet Directive 2002/95/EC..
- CE & UKCA certified



POTENTIAL APPLICATIONS

- Medical: Anesthesia delivery machines, ventilators, ventricular assist devices (heart pumps), spirometers, laparoscopy
- Industrial: Analytic instrumentation (spectrometry, chromatography), air-to-fuel ratio, fuel cells, fume hoods, gas leak detection, process control gas monitoring, vacuum pump monitoring



PORTFOLIO

The Honeywell Zephyr Digital Airflow Sensors join an extensive line of airflow sensors for potential use in medical, industrial, and consumer applications.

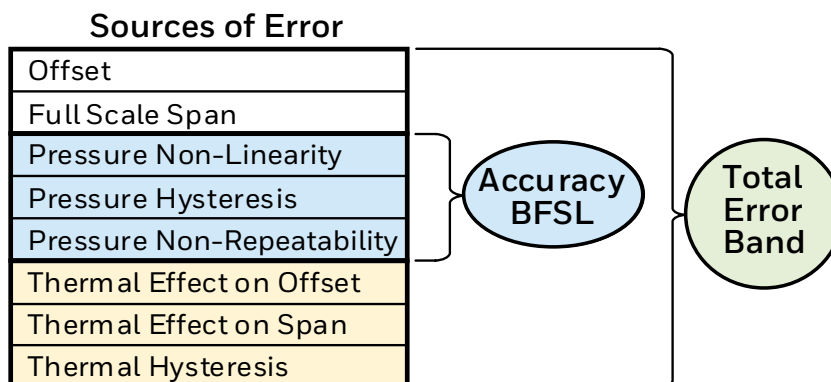
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FIGURE 1. TOTAL ERROR BAND VS. ACCURACY

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.

- 0%FS to 14.3%FS = 0.5%FS
- 14.3%FS to 100%FS = 3.5%reading

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, 15, 20, 50, 100, 200 SLPM:
 - 0%FS to 12.5%FS = 0.5%FS
 - 12.5%FS to 100%FS = 4.0%reading
- 300 SLPM only:
 - 0%FS to 12.5%FS = 0.5%FS
 - 12.5%FS to 66.7%FS = 4.0%reading
 - 66.7%FS to 100%FS = 7.0%reading

TABLE 1. ABSOLUTE MAXIMUM RATINGS¹

| 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 ² |
| Storage temperature range | -40°C to 100°C [-40°F to 212°F] |
| Maximum flow change | 10,000 SLPM/s |
| Maximum common mode pressure | 4 bar 60 psi at 25°C [77°F] |
| Maximum flow | 350 SLPM |

¹Absolute 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.

²Digital 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.

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| 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 ¹ | 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 ² | 10, 15, 20, 50, 100, 200, 300 SLPM |
| Calibrated flow range | 0 to 10, 0 to 15, 0 to 20, 0 to 50, 0 to 100, 0 to 200, 0 SLPM to 300 SLPM |
| Calibration gas | clean, dry air |
| Accuracy ³ | |
| 0%FS to 14.3%FS | 0.5%FS |
| 14.3%FS to 100%FS | 3.5%reading |
| Total Error Band: ⁴ | |
| 10, 15, 20, 50, 100, 200 SLPM: | |
| 0%FS to 12.5%FS | 0.5%FS |
| 12.5%FS to 100%FS | 4.0%reading |
| 300 SLPM only: | |
| 0%FS to 12.5%FS | 0.5%FS |
| 12.5%FS to 66.7%FS | 4.0%reading |
| 66.7%FS to 100%FS | 7.0%reading |
| Null accuracy ⁵ | ±0.5%FS |
| Flow response time ⁶ | 1 ms |
| Warm up time ⁷ | 35 ms |
| Resolution: | |
| 10 SLPM | 0.002 SLPM |
| 15 SLPM | 0.003 SLPM |
| 20 SLPM | 0.003 SLPM |
| 50 SLPM | 0.008 SLPM |
| 100 SLPM | 0.015 SLPM |
| 200 SLPM | 0.029 SLPM |
| 300 SLPM | 0.043 SLPM |
| Proof pressure | 10.3 bar 150 psig |
| Burst pressure | 13.7 bar 200 psig |
| Bus standards ⁸ | I ² C fast mode (up to 400 kHz) |
| Reverse polarity protection | no |

¹ Custom and extended temperature compensated ranges are possible. Contact Honeywell for details.

² 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.

³ 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.

⁴ 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.

⁵ Null Accuracy is the maximum deviation in output from nominal at null flow over the entire calibrated temperature range.

⁶ 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).

⁷ Warm-up time: time to the first valid flow measurement after power is applied.

⁸ Refer to the Technical Note "I²C Communications with Honeywell Digital Airflow Sensors" for I²C protocol information.

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TABLE 3. 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: 20, 50, 100, 200, 300 SLPM 10, 15 SLPM | Level 3 from 80 MHz to 1000 MHz per IEC61000-4-3 1 m shielded cable with 3 cm exposed leads at connector 1 m shielded cable with 3 cm exposed leads at connector and 280 Ohm at MHz ferrite bead |

TABLE 4. 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 |

TABLE 5. 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 |

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FIGURE 2. NOMENCLATURE AND ORDER GUIDE¹

For example, **HAFUHM0020L4AXT** defines a Honeywell Zephyr™ Airflow Sensor, unidirectional flow, long port, manifold mount, 20 SLPM, I²C 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 | | | | | |
| HAF Series— High Accuracy Airflow Sensor | U Unidirectional | HM Manifold mount | 0010 10 | L SLPM | 2 Digital I ² C address: 0x29 | A 10% to 90% of input | X XXXXX | T 3 Vdc to 10 Vdc | | | | | |
| | | | 0015 15 | | 3 Digital I ² C address: 0x39 | | | | | | | | |
| | | | 0020 20 | | 4 Digital I ² C address: 0x49 | | | | | | | | |
| | | HH 22 mm OD tapered male fitting per ISO 5356 | 0050 50 | | 5 Digital I ² C address: 0x59 | | | | | | | | |
| | | | HT G 3/8 female threaded fitting per ISO 1179 | | 0100 100 | | | | 6 Digital I ² C address: 0x69 | | | | |
| | | | | | 0200 200 | | | | 7 Digital I ² C address: 0x79 | | | | |
| | | | | | 0300 300 | | | | | | | | |

¹Apart 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, 15, 20, 50, 100, 200, 300 SLPM

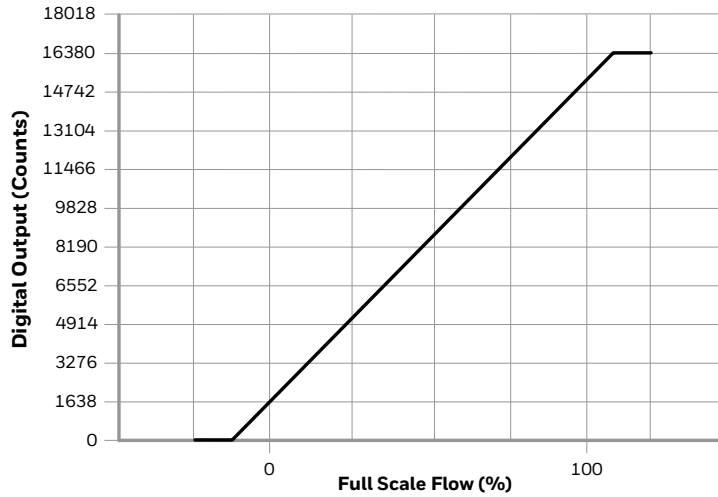
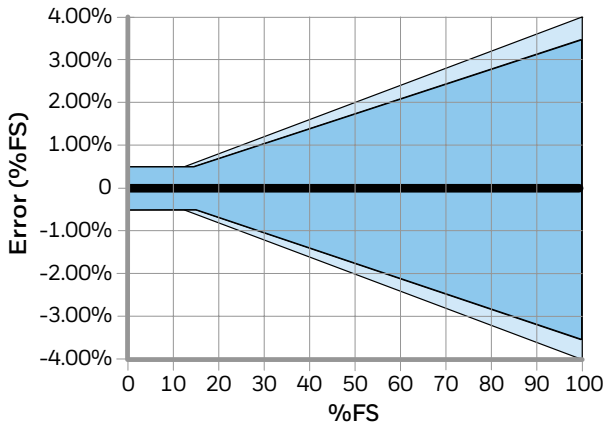
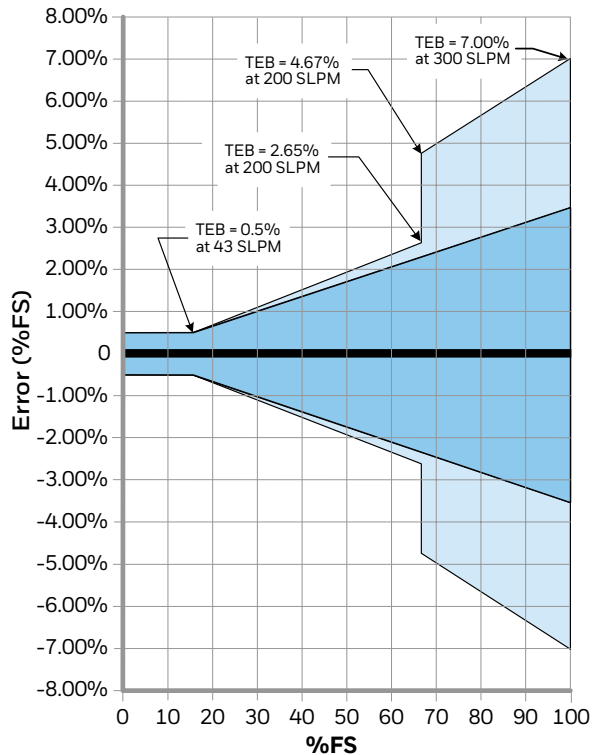


FIGURE 5. ACCURACY AND TOTAL ERROR BAND
10, 15, 20, 50, 100, 200 SLPM

300 SLPM only



- 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%
12.5%FS to 100%FS = 4.0%

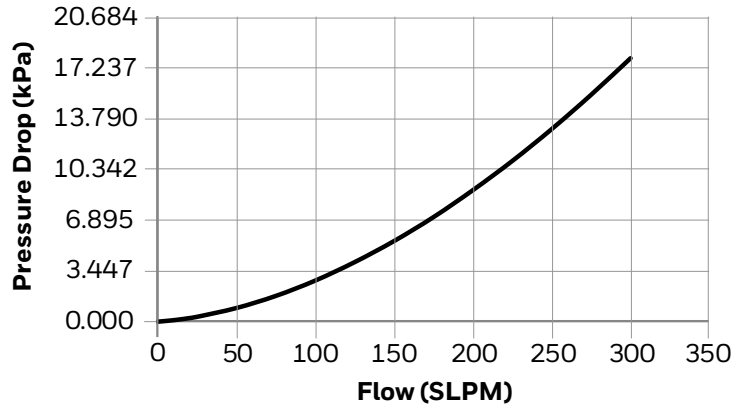


- Ideal**
- Accuracy:**
0%FS to 14.3%FS (0 SLPM to 43 SLPM) = 0.5%
14.3%FS to 100%FS (43 SLPM to 300 SLPM) = 3.5%
- Total Error Band:**
0%FS to 14.3%FS (0 SLPM to 43 SLPM) = 0.5%
14.6%FS to 66.7%FS (44 SLPM to 200 SLPM) = 4.0%
66.7%FS to 100%FS (200 SLPM to 300 SLPM) = 7.0%

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FIGURE 6. FLOW VS PRESSURE DROP: 10, 15, 20, 50, 100, 200, 300 SLPM



| Flow (SLPM) | Typical Pressure Drop | | |
|-------------|-----------------------|--------------------|--------|
| | mbar | inH ₂ O | kPa |
| 0 | 0.000 | 0.000 | 0.000 |
| 1 | 0.103 | 0.042 | 0.010 |
| 2 | 0.206 | 0.082 | 0.021 |
| 4 | 0.396 | 0.159 | 0.040 |
| 8 | 0.803 | 0.322 | 0.080 |
| 10 | 1.027 | 0.412 | 0.103 |
| 12 | 1.279 | 0.513 | 0.128 |
| 14 | 1.549 | 0.621 | 0.155 |
| 15 | 1.686 | 0.676 | 0.169 |
| 16 | 1.820 | 0.730 | 0.182 |
| 18 | 2.126 | 0.853 | 0.213 |
| 20 | 2.444 | 0.980 | 0.244 |
| 25 | 3.320 | 1.332 | 0.332 |
| 50 | 9.314 | 3.736 | 0.931 |
| 75 | 17.553 | 3.736 | 1.755 |
| 100 | 27.979 | 3.736 | 2.798 |
| 125 | 40.533 | 3.736 | 4.053 |
| 150 | 54.881 | 22.017 | 5.488 |
| 175 | 71.158 | 28.546 | 7.116 |
| 200 | 89.506 | 35.907 | 8.951 |
| 225 | 109.363 | 43.873 | 10.936 |
| 250 | 131.037 | 52.568 | 13.104 |
| 275 | 154.389 | 61.936 | 15.439 |
| 300 | 179.235 | 71.904 | 17.924 |

TABLE 6. 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

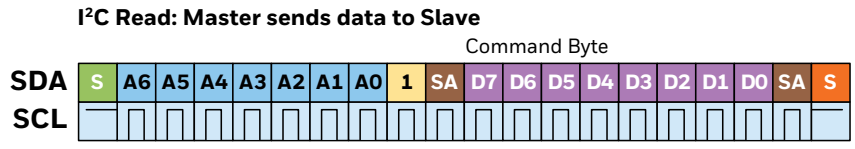
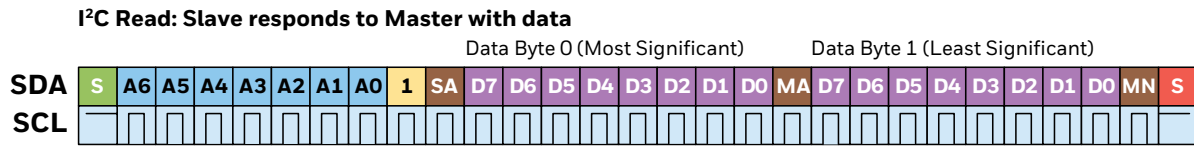
For additional details on the use of Zephyr with digital output see the Technical Note “I²C Communications with Honeywell Digital Airflow Sensors”.

The sensor uses the I²C 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 I²C READ AND WRITE SEQUENCES



| Bit | Name | Description |
|-----|-----------------|--|
| S | Start condition | Master pulls SDA from high to low while SCL remains high |
| S | Stop condition | Master allows SDA to float from low to high while SCL remains high |
| A6 | Address bit | I ² C Slave Address is the 7 Most Significant Bits for the first transmitted byte |
| 1 | Read/write bit | Read = 1, Write = 0 |
| D7 | Data bit | Read = 1, Write = 0 |
| SA | Slave ACK | Slave pulls SDA low |
| MA | Master ACK | Master pulls SDA low |
| MN | Master NACK | Master allows SDA to float high |

After the power-up read sequence described above, the sensor will respond to each I²C 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 8. Following an I²C write sequence of a user command, the sensor will respond to the next I²C read request with a 16-bit response. Possible responses to user commands can be seen in Table 9.

TABLE 8. 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 9. 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 |

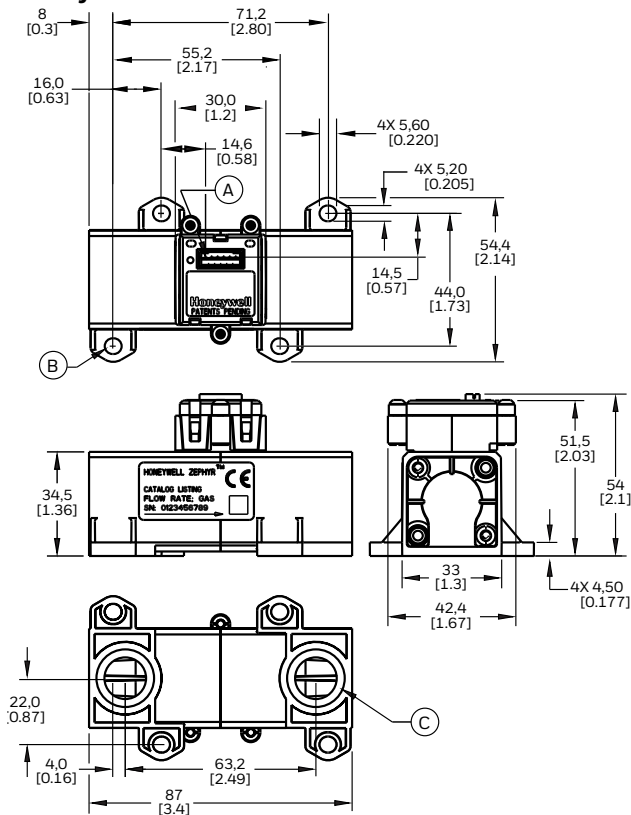
The maximum sink current on SCL or SDA is 2 mA. Therefore, if the pull-up resistors are biased by VDD, and if VDD reaches the maximum supply voltage of 6 V, then the pull-up resistors for SCL and SDA must be greater than 3.0 kOhm to limit the sink current to 2 mA. The typical value for SCL and SDA pull-up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

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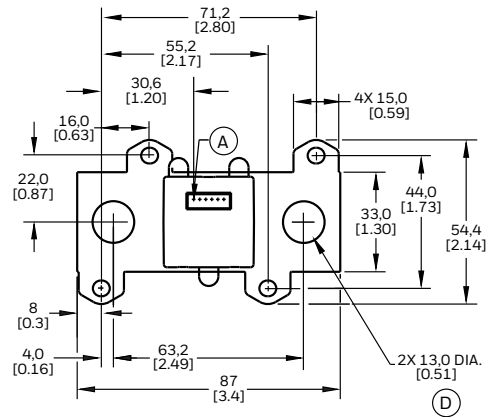
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FIGURE 8. MOUNTING DIMENSIONS (FOR REFERENCE ONLY: MM [IN.])

Port Style: Manifold Mount

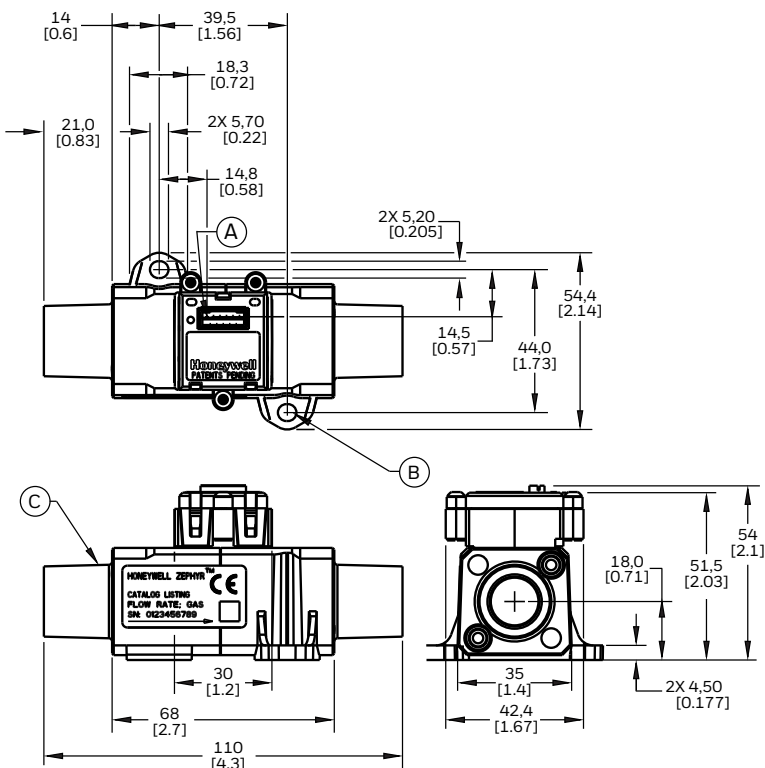


Mounting Footprint

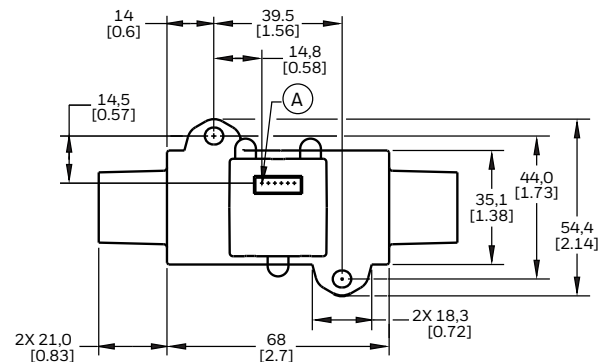


- (A) Pin 1.
- (B) 4X 10-32 pan head screws 1,13 N m [20 in-lb] torque.
- (C) 2X Gland for O-Ring AS568-113, 13,94 mm ID x 2,62 mm [0.549 in ID x 0.103 in W. Two O-rings, AS568A-113 Durometer A65 to A80 Silicon or Viton, are required to seal sensor to manifold. O-rings are not included.
- (D) Flow channel.

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



Mounting Footprint



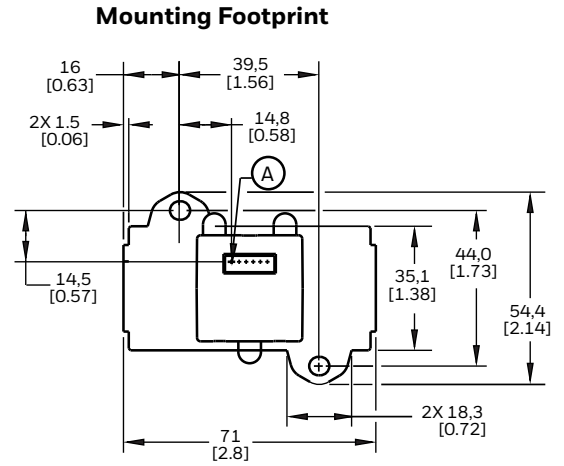
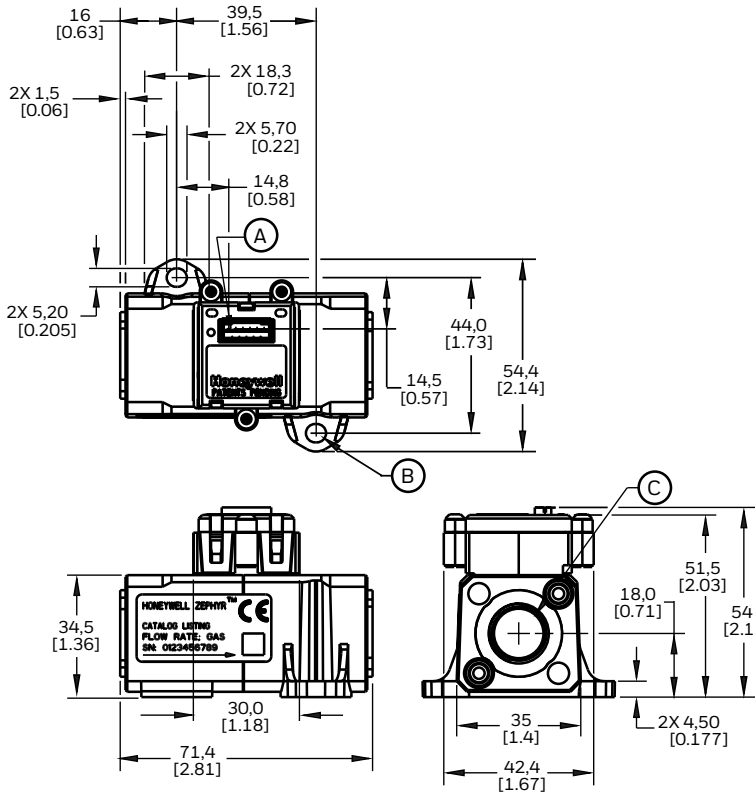
- (A) Pin 1.
- (B) 2X 10-32 pan head screws 1,13 N m [20 in-lb] torque.
- (C) 15 mm ID/22 mm OD tapered fitting per ISO 5356.

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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



- (A) Pin 1.
- (B) 2X 10-32 pan head screws 1,13 N m [20 in-lb] torque.
- (C) ISO 1179 G3/8, recommended torque is 1,7 ±0,6 N m [15 ±5 in lb]. Electrical connector part number is JST (Japan Solderless Terminals) B6B-PH-K-S. Mating connector part numbers are JST PHR-6 (socket) and JST SPH-002T-P0.5L (crimp terminal).

TABLE 7. PINOUT (DIGITAL FUNCTION)

| Pin 1 | Pin 2 | Pin 3 | Pin 4 | Pin 5 | Pin 6 |
|-------|-------|-------|--------|-------|-------|
| NC | SCL | VVDD | ground | SDA | NC |