

## Sensors in Anesthesia Machines

### An Application Note

#### Background

A medical anesthesia machine is designed to deliver drugs that help to eliminate pain and other unwanted sensations.

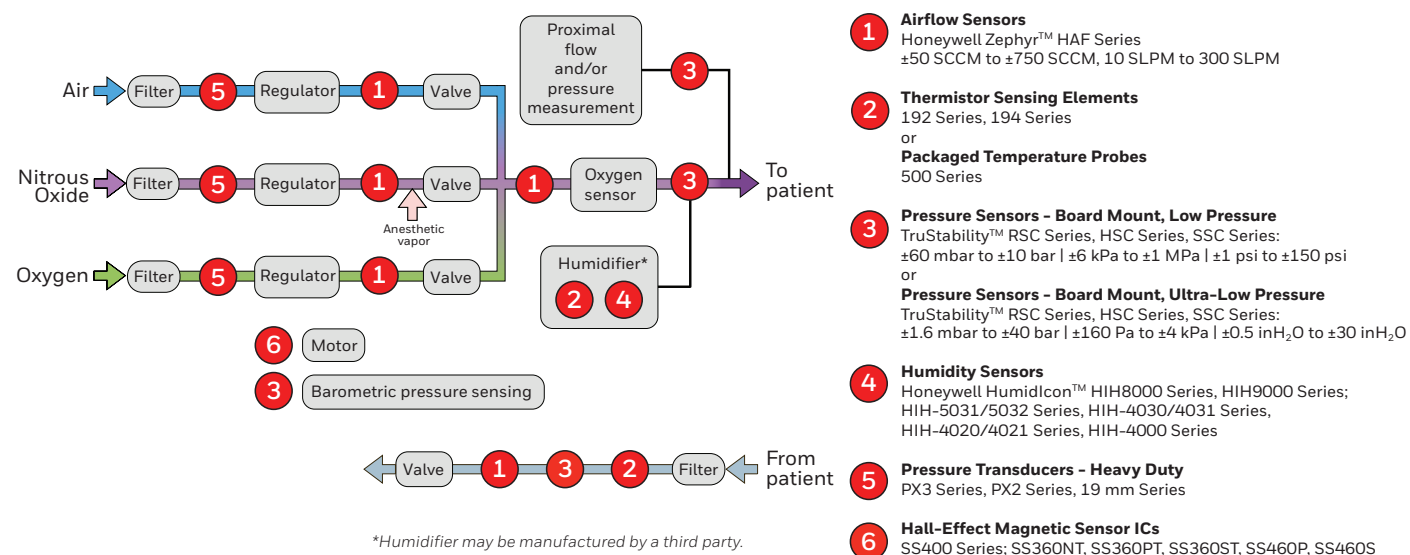
The continuous flow anesthetic machine provides an accurate and constant supply of medical gases (such as air, nitrous oxide, and oxygen) mixed with an accurate concentration of anesthetic vapor (such as isoflurane), and delivers this mixture to the patient at a desired pressure and flow.

#### Solutions

Honeywell manufactures many products that may be used in anesthesia machines. They are designed to help control, airflow, temperature, pressure and humidity, as well as to provide output for smooth motor control. (See Figure 1.)



**Figure 1. Potential Honeywell Products Used in Anesthesia Machines**

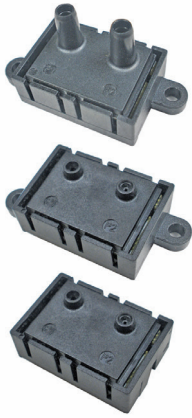



## Airflow Sensors

Airflow sensors are designed to measure the flow of air and oxygen. They may be used so that the desired mixture, as set by the doctor, is delivered to the patient. The total mixture that is delivered to the patient is also measured and displayed on the ventilator panel. (See Table 1.)

**Customer Benefits:** Improves patient comfort, eases patient breathing, reliable

**Table 1. Airflow Sensors**

HONEYWELL ZEPHYR™ ANALOG OR DIGITAL AIRFLOW SENSORS, HAF SERIES, ±50 SCCM TO ±750 SCCM	FEATURES
	<ul style="list-style-type: none"> <li>• Total Error Band as low as ±0.25 %FSS allows for precise airflow measurement</li> <li>• Fast response time (1 ms)</li> <li>• Wide range of airflows: ±50, ±100 ±200, ±400 or ±750 SCCM, or custom flow ranges</li> <li>• Customizable flow ranges and configurable package styles</li> <li>• Full calibration and temperature compensation</li> <li>• Linear output</li> <li>• Low pressure drop typically improves patient comfort and reduces noise and system wear</li> <li>• 0.039% FS resolution (analog version) or high 12-bit resolution (digital version) increases ability to sense small airflow changes</li> <li>• Low 3.3 Vdc operating voltage option and low power consumption</li> <li>• ASIC-based I<sup>2</sup>C digital output (digital version) compatibility</li> <li>• Insensitivity to altitude</li> <li>• Small size</li> <li>• RoHS-compliant materials meet Directive 2002/95/EC</li> </ul>
HONEYWELL ZEPHYR™ DIGITAL AIRFLOW SENSORS, HAF SERIES: 10 SLPM TO 300 SLPM	FEATURES
	<ul style="list-style-type: none"> <li>• Industry's smallest Total Error Band allows for precise airflow measurement</li> <li>• High accuracy</li> <li>• Fast response time (1 ms)</li> <li>• High stability</li> <li>• High sensitivity at very low flows</li> <li>• High 12-bit resolution</li> <li>• Wide airflow range measures mass flow with standard flow ranges of 10 SLPM, 15 SLPM, 20 SLPM, 50 SLPM, 100 SLPM, 200 SLPM or 300 SLPM, or custom flow ranges</li> <li>• Choice of port styles</li> <li>• Linear output</li> <li>• Wide supply voltage range (3 Vdc to 10 Vdc)</li> <li>• ASIC-based I<sup>2</sup>C digital output</li> <li>• Factory or custom calibration for multiple gas types</li> <li>• RoHS-compliant materials meet Directive 2002/95/EC</li> </ul>



## Thermistor Sensing Elements

Air that is warm and moist helps to provide the patient with a comfortable breathing situation and may reduce sore throats caused by breathing cold, dry air. As such, the temperature of the air delivery system is often monitored and controlled to help ensure that the air stream is maintained at the desired level of warmth. The 192 Series and 194 Series are installed directly into the air stream and are designed to monitor and control the air temperature. The sensor is coupled to a microcontroller designed to measure air stream temperature and interact with the controller which controls and regulates the temperature of the air stream. Honeywell offers

several types of configurations. The packaged sensors are available as discrete components for customer-built assemblies, or Honeywell can provide a full assembly solution that the customer may simply pigtail into the system. (See Table 2.)

**Customer Benefits:** Flexible, cost effective, small


**Table 2. Thermistor Sensing Elements**

192 SERIES	FEATURES
	<ul style="list-style-type: none"> <li>• Bare leads (192 Series) or insulated leads (194 Series)</li> <li>• Resistance temperature (R-T) curve interchangeability designed to offer standardization of circuit components and simplification of design/replacement, as well as potential cost savings</li> <li>• Small size often eases use in confined spaces</li> </ul>
<p data-bbox="115 852 237 894">194 SERIES</p> 	

## Packaged Temperature Probes

These products may perform the same function as the Thermistor Sensing Elements. (See Table 3.)

**Table 3. Packaged Temperature Probes**

500 SERIES	FEATURES
	<ul style="list-style-type: none"> <li>• Packaged assembly</li> <li>• Wide selection of housing, resistance, and termination options accommodate air/gas, fluid immersion or surface sensing requirements</li> <li>• Variety of custom or off-the-shelf thermistor and RTD-based solutions</li> </ul>

### Pressure Sensors - Board Mount, Low and Ultra-Low

Board mount pressure sensors are designed to measure air and oxygen pressure to and from the patient so the pressure doesn't exceed a desired level. (See Table 4.)

**Customer Benefits:** Stable, accurate, easy to use, easy to design in, improves patient safety, compatible

**Table 4. Low and Ultra-Low Pressure Sensors**

TRUSTABILITY™ RSC SERIES, HSC SERIES, SSC SERIES	FEATURES
	<ul style="list-style-type: none"> <li>• Proprietary Honeywell technology combines high sensitivity with high overpressure and burst pressure while providing industry leading stability, performance factors difficult to achieve in the same product</li> <li>• Industry-leading accuracy:             <ul style="list-style-type: none"> <li>- RSC Series: <math>\pm 0.1\%</math> FSS BFSL</li> <li>- HSC Series and SSC Series: <math>\pm 0.25\%</math> FSS BFSL</li> </ul> </li> <li>• Provides greater than 18 bits of real resolution (RSC Series)</li> <li>• Wide pressure range: <math>\pm 1.6</math> mbar to <math>\pm 10</math> bar   <math>\pm 160</math> Pa to <math>\pm 1</math> MPa   <math>\pm 0.5</math> inH<sub>2</sub>O to <math>\pm 150</math> psi</li> <li>• Miniature package size</li> <li>• Extremely low power consumption</li> <li>• Temperature compensation and calibration provide an amplified signal</li> <li>• Digital ASIC output in either I<sup>2</sup>C or SPI protocols from digital sensors accelerates performance through reduced conversion requirements and the convenience of direct interface to microprocessors and microcontrollers</li> <li>• Multiple packaging, mounting, power and signal options and customized calibration capabilities increase flexibility</li> <li>• REACH and RoHS compliant</li> <li>• RoHS-compliant materials meet Directive 2002/95/EC</li> </ul>

## Humidity Sensors

These sensors may be used to deliver warm and moist air, which often enhances patient comfort. When introducing moisture into the air stream, it must be monitored and controlled. Honeywell’s humidity sensors are installed either directly into the air stream or in a parallel branch. The sensor is coupled to a microcontroller designed to measure the humidity of the air stream and to interact with the controller that ensures the correct level of moisture is present. (See Table 5.)

**Customer Benefits:** Accurate, flexible, cost effective, durable

**Table 5. Humidity Sensors**

HONEYWELL HUMIDICON™ HIH8000 SERIES, HIH9000 SERIES		FEATURES
		<ul style="list-style-type: none"> <li>• Industry-leading long term stability (1.2 %RH over five years)</li> <li>• Industry-leading reliability (MTTF 9,312,507 HR)</li> <li>• Lowest total cost solution due to being an industry-leading combined humidity/temperature sensor</li> <li>• Low supply voltage and low power consumption</li> <li>• High 14-bit humidity sensor resolution and 14-bit temperature sensor resolution</li> <li>• True, temperature-compensated digital I<sup>2</sup>C or SPI output</li> <li>• SOIC-8 SMD (Surface Mount Device) or SIP 4 Pin</li> <li>• Ultra small size</li> <li>• Available with hydrophobic filter and condensation-resistance</li> <li>• Tape and reel allows for use in high volume, automated pick-and-place manufacturing</li> <li>• Wide operating temperature range of -40°C to 125°C [-40°F to 257°F]</li> <li>• Optional one or two %RH level alarm outputs</li> <li>• Multi-function ASIC</li> <li>• RoHS and WEEE compliant, halogen-free</li> </ul>
HIH-4030/4031 SERIES , HIH-5030/5031 SERIES		FEATURES
		<ul style="list-style-type: none"> <li>• Multilayer construction designed to provide enhanced resistance to wetting, dirt, and common environmental chemicals</li> <li>• Available covered, filtered/unfiltered for application flexibility</li> <li>• Surface mount design</li> <li>• Low current draw</li> <li>• Factory calibration data designed to provide individually matched downstream electronics and accuracy</li> <li>• Voltage supply:               <ul style="list-style-type: none"> <li>- HIH-5030/5031: 2.7 Vdc to 5.5 Vdc</li> <li>- HIH-4030/4031: 4 Vdc to 5.8 Vdc</li> </ul> </li> </ul>
HIH-4020/4021 SERIES	HIH-4000 SERIES	FEATURES
		<ul style="list-style-type: none"> <li>• Instrumentation-quality RH sensing performance in a competitively priced, solderable SIP</li> <li>• Accurate, fast response</li> <li>• Multilayer construction provides enhanced resistance to wetting, dirt, and common environmental chemicals</li> <li>• Laser trimmed for stable, low drift performance</li> <li>• Factory calibration data designed to provide individually matched downstream electronics and accuracy</li> <li>• HIH-4020/4021 Series: Available covered/uncovered and filtered/unfiltered</li> </ul>

## Pressure Transducers - Heavy Duty

Heavy duty pressure transducers are designed to provide a sensing solution when high pressure, steel pressure port interface and/or corrosive media are present. A male threaded pressure port and stainless steel wetted surfaces provide an air and oxygen inlet. (See Table 6.)

**Customer Benefits:** Stable, easy to use, accurate, improves patient safety, easy to design in, compatible

**Table 6. Heavy Duty Pressure Transducers**

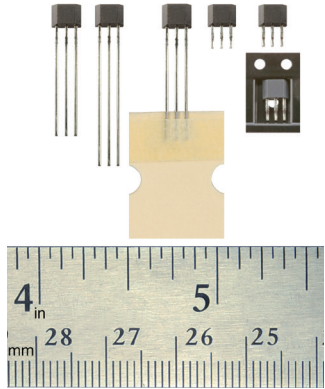
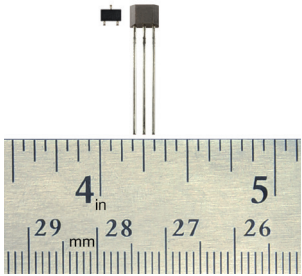
PX3 SERIES	FEATURES
	<ul style="list-style-type: none"> <li>• Pressure range: 1 bar to 50 bar   15 psi to 700 psi (absolute and sealed gage)</li> <li>• Ratiometric output: 0.5 Vdc to 4.5 Vdc or 0.33 Vdc to 2.97 Vdc</li> <li>• Fully calibrated and temperature compensated</li> <li>• Total Error Band: <math>\pm 1.0\%</math> FSS from <math>-20^{\circ}\text{C}</math> to <math>85^{\circ}\text{C}</math> [<math>-4^{\circ}\text{F}</math> to <math>185^{\circ}\text{F}</math>]</li> <li>• External freeze/thaw resistance: 6 cycles from <math>-30^{\circ}\text{C}</math> to <math>50^{\circ}\text{C}</math> [<math>-22^{\circ}\text{F}</math> to <math>122^{\circ}\text{F}</math>]</li> <li>• Insulation resistance: <math>&gt;100\text{ MOhm}</math>, 1500 Vdc (in dry, nonionized air)</li> <li>• Dielectric strength: AC1500V, 1 min. or AC1800V, 1 s (in dry, nonionized air)</li> <li>• Current consumption: 3.5 mA max</li> <li>• EMC (radiated immunity): 200 V/m per ISO 11452-2</li> <li>• Ingress protection IP67 (Metri-Pack 150), IP69K (cable harness)</li> <li>• Response time: <math>&lt;2\text{ ms}</math></li> <li>• RoHS, REACH, and CE compliant</li> <li>• Six industry-standard pressure port types, including a tube port which provides for hermetically-sealed process connection</li> </ul>
PX3 SERIES	FEATURES
	<ul style="list-style-type: none"> <li>• Pressure range: 1 bar to 70 bar   100 kPa to 7 MPa   15 psi to 1000 psi</li> <li>• Pressure reference: Absolute, sealed gage or vented gage</li> <li>• Pressure port types: 7/16-20 UNF 1/4 in 45° Flare Female Schrader (SAE J512), 7/16-20 UNF 45° Flare Male (SAE J513), 7/16-20 UNF 37° Flare Male (SAE J514), G1/4 (ISO 1179-3), G1/8 (ISO 1179-3), M12 x 1.5 (ISO 6149-3), 1/4-18 NPT, 1/8-27 NPT, 9/16-18 UNF, (SAE J1926-3), or 7/16-20 UNF (SAE J1926-3)</li> <li>• Electrical connector types: Metri-Pack 150 (UL 94 HB or V-0 options), Micro M12, DIN, Deutsch, or cable harness (1 m, 2 m, 3 m, or 5 m)</li> <li>• Total Error Band: <math>\pm 2.0\%</math></li> <li>• Operating and compensated temperature range: <math>-40^{\circ}\text{C}</math> to <math>125^{\circ}\text{C}</math> [<math>-40^{\circ}\text{F}</math> to <math>257^{\circ}\text{F}</math>]</li> <li>• Response time: <math>&lt;2\text{ ms}</math></li> <li>• Life: Minimum of 10 million cycles to operating pressure</li> <li>• Output transfer function: Ratiometric, regulated or current</li> <li>• Mechanical shock rating: 100 G per MIL-STD-202F, Method 213B, Cond. F</li> <li>• Vibration rating: 20 G sweep, 10 Hz to 2000 Hz</li> <li>• Ingress protection: Up to IP69K</li> <li>• Radiated immunity protection: Up to 100 V/m (ISO 11452-2)</li> <li>• Flame retardant options: UL 94 HB standard on all electrical terminations; UL 94 V-0 available upon request</li> </ul>
19 MM SERIES	FEATURES
	<ul style="list-style-type: none"> <li>• Low cost</li> <li>• Rugged, isolated stainless steel package</li> <li>• Small size</li> <li>• Reliable semiconductor technology</li> <li>• Calibrated and temperature compensated</li> <li>• Absolute and gage pressures</li> <li>• Vacuum compatible, isolated sensors</li> <li>• 0 psi to 3 psi to, 0 psi to 500 psi</li> </ul>

### Hall-effect Magnetic Sensor ICs

These products are designed to provide enhanced output accuracy for smooth motor control that reduces noise and vibration in motor assembly fan systems. Their small size often reduces replacement costs and allows for design into many compact, automated, lower-cost assemblies. A thermally-balanced integrated circuit that is accurate over a full temperature range is designed to provide proper fan functionality. (See Table 7.)

**Customer Benefits:** Quiet, durable, cost effective, improves patient safety, efficient, effective, accurate.

**Table 7. Hall-effect Magnetic Sensor ICs**

SS400 SERIES	FEATURES
	<ul style="list-style-type: none"> <li>• Quad Hall-effect design minimizes effects of mechanical or thermal stress on output, and promotes a stable output</li> <li>• Unipolar, bipolar or latching magnetics and customizable operate/release points</li> <li>• Negative compensation slope optimized to match negative temperature coefficient of lower-cost magnets, providing robust design over wide temperature range</li> <li>• Band gap regulation promotes stable operation over supply voltage range</li> <li>• Low power consumption enhances energy efficiency</li> </ul>
S360NT, S360ST, SS460S; SS360PT, SS460P	FEATURES
	<ul style="list-style-type: none"> <li>• Fastest response time in its class</li> <li>• No chopper stabilization</li> <li>• High sensitivity</li> <li>• Latching magnetics</li> <li>• Built-in reverse voltage</li> <li>• Durable design</li> <li>• RoHS-compliant material meets Directive 2002/95</li> </ul>

## **Warranty/Remedy**

Honeywell warrants goods of its manufacture as being free of defective materials and faulty workmanship during the applicable warranty period. 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 that Honeywell, in its sole discretion, 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.**

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