Sensors and Flexible Heaters in Ventilator Applications

BACKGROUND

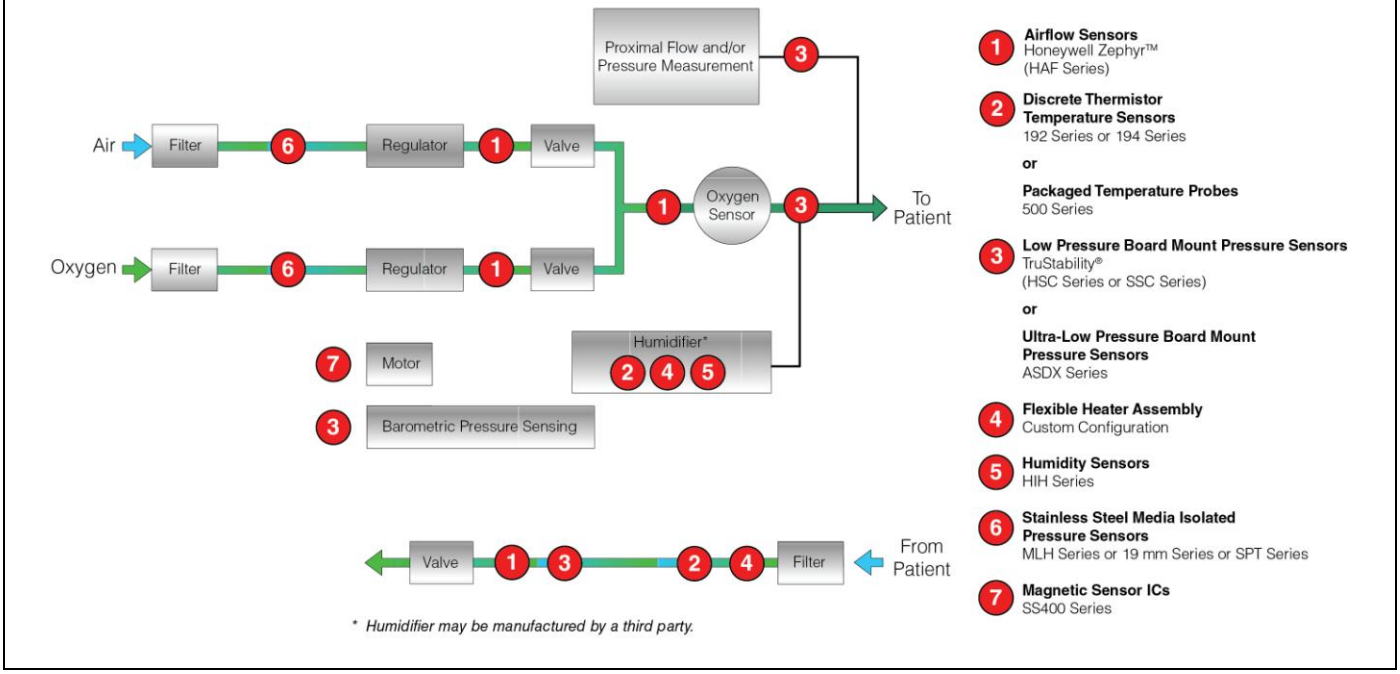
A medical ventilator is designed to move a mixture of air and oxygen into and out of the patient's lungs to either assist in breathing or, in some cases, mechanically breathe for the patient who is breathing insufficiently or is physically unable to breathe. (See Figure 1.)

SOLUTIONS

Honeywell manufactures many products that may be used in ventilators. They are designed to help control pressure, airflow, temperature and humidity, as well as to provide output for smooth motor control. (See Figure 2.)

Figure 1. Ventilator

Figure 2. Potential Honeywell Products used in Ventilators



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Pressure Sensors

Low Pressure Board Mount: TruStability® Board Mount Pressure Sensors (HSC Series and SSC Series) are designed to measure air and oxygen pressure to and from the patient so the pressure doesn't exceed a desired level. (See Table 1.)

Ultra-Low Pressure Board Mount: The ASDX Series is also designed to measure air and oxygen pressure to and from the patient so the pressure doesn't exceed a desired level. The CPC Series (*CPCL10GFC*) and the SDX010IND4 may also be used; however, they also require a customer-provided amplifier or an ASIC-based solution for a signal conditioned output. Although this option may provide the customer with increased design flexibility, it may take longer to design and may use more board space than the ASDX Series. (See Table 1.)

Stainless Steel Media Isolated: The MLH Series, 19 mm Series, and SPT Series pressure sensors 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 2.)

Table 1. Board Mount Pressure Sensors

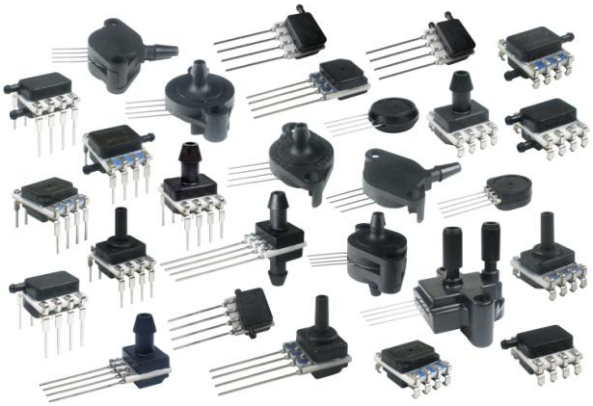
TruStability® Board Mount Pressure Sensors (HSC Series and SSC Series)	ASDX Series
	
Features and Benefits	
• Temperature compensation and calibration provide an amplified signal, typically allowing removal of components associated with signal conditioning from the PCB, increasing space and reducing associated costs • Industry-leading stability often eliminates need for calibration after PCB mount, and periodically over time • Digital ASIC output in either I^2C or SPI protocols from digital sensors accelerates performance through reduced conversion requirements and the convenience of direct interface to microprocessors and microcontrollers • Multiple packaging, mounting, power, and signal options combine with customized calibration capabilities to increase flexibility	• Repeatable output designed for enhanced accuracy and sensitivity over range of device • Customizable output designed for application flexibility • Fully compensated for ease of use

Table 2. Stainless Steel Media Isolated Pressure Sensors

MLH Series	19 mm Series	SPT Series	Features and Benefits
			• Media isolated transducer (stainless steel wetted surfaces) designed for compatibility with many corrosive fluids and gases • Threaded pressure port designed for easy installation in customer manifold • Optional weldable interface designed to support a hermetic interface • Temperature-compensated electrical output • Amplified and non-amplified options

Airflow Sensors

The Honeywell Zephyr™ Airflow Sensors (HAF Series) are designed to measure the flow of air and oxygen. They may 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 3.)

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Table 3. Airflow Sensors

Honeywell Zephyr™ Airflow Sensors (HAF Series)	Features and Benefits (★ = *competitive differentiator)*
	• High 12-bit resolution (digital) or high 11-bit resolution (analog) increases the ability to sense small airflow changes, allowing for more precise control of the application ★**Meet high accuracy specifications:** High 2.5% accuracy allows for very precise airflow measurement, often ideal for demanding applications with high accuracy requirements ★**Customizable:** Allows the sensor to be designed to meet specific end-user needs ★**High sensitivity at very low flows:** Allows the customer's application to detect presence or absence of airflow ★**High stability:** Reduces errors due to thermal effects and null shift to provide accurate readings over time, often eliminating need for system calibration after printed circuit board mount, and periodically over time ★**Low pressure drop:** Low pressure drop typically improves patient comfort in medical applications, and reduces noise and system wear in components such as motors/pumps ★**Saves customers time and money:** Linear output provides a more intuitive sensor signal than the raw output of basic airflow sensors, often eliminating the need for customers having to linearize the output which can help to reduce production and design costs and implementation time • **Simplifies customer's production requirements:** ASIC-based I^2C digital output compatibility eases integration to micro-processors or micro-controllers, reducing PCB complexity and component count • **Small:** 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 • **Flexible:** Low 3.3 Vdc voltage option and low power supply allows for battery-driven and other portable applications

Discrete Thermistor Temperature Sensors

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 4.)

Table 4. Discrete Thermistor Temperature Sensors

192 Series, 194 Series	Features and Benefits
	• Bare leads (192 Series) or insulated leads (194 Series) designed for improved application flexibility • Resistance temperature (R-T) curve interchangeability designed to offer standardization of circuit components and simplification of design/replacement, as well as potential cost savings • Small size often eases use in confined spaces

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Packaged Temperature Probes

These products may perform the same function as the Discrete Thermistor Temperature Sensors. (See Table 5.)

Table 5. Packaged Temperature Probes

500 Series	Features and Benefits
	• Packaged assembly • Wide selection of housing, resistance, and termination options accommodate air/gas, fluid immersion or surface sensing requirements • Variety of custom or off-the-shelf thermistor and RTD-based solutions

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 6.)

Table 6. Humidity Sensors

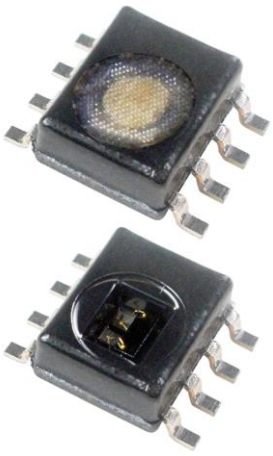
Honeywell HumidIcon™ Digital Humidity/Temperature Sensors: HIH6130/6131 Series	Features and Benefits (★ = competitive differentiator)
	★ **Industry-leading long term stability (1.2 %RH over five years):** Minimizes system performance issues, helps support system uptime by eliminating the need to service or replace the sensor during its application life, and eliminates the need to regularly recalibrate the sensor ★ **Industry-leading Total Error Band (TEB) (±5 %RH)** (Over a compensated range of 5 °C to 50 °C [41 °F to 122 °F] and 10% RH to 90% RH): Eliminates individual sensor testing and calibration, supports system accuracy and warranty requirements, helps to optimize system uptime, and provides excellent sensor interchangeability ★ **Industry-leading reliability:** Laser trimmed, thermoset polymer capacitive sensing element's multilayer construction provides resistance to most application hazards ★ **Lowest total cost solution:** Due to the sensor's industry-leading Total Error Band and its being a combined humidity/temperature sensor ★ **True, temperature-compensated digital I^2C output:** Typically allows the customer to remove the components associated with signal conditioning from the PCB ★ **Energy efficient:** Can operate down to 2.3 Vdc, allowing use in low energy and wireless-compatible applications to enhance energy savings and prolong system battery life. The sensor goes into sleep mode when not taking a measurement within the application, consuming only 1 µA of power versus 650 µA in full operation in a battery operated system ★ **Ultra-small SOIC-8 SMD (Surface Mount Device) package:** Allows for flexibility of use ★ **Combined humidity and temperature sensor in one package:** Allows the RH measurement to be temperature compensated and provides a second, standalone temperature sensor output. ★ **Cost-effective tape and reel packaging:** Allows for use in high volume, automated pick-and-place manufacturing, eliminating lead misalignment to the PCB and helping the customer to reduce manufacturing costs ★ **High resolution:** High 14-bit humidity sensor resolution and 14-bit temperature sensor resolution within the application help the user's system detect the smallest RH or temperature change ★ **Wide operating temperature range** of -25 °C to 85 °C [-13°F to 185 °F]: Allows for use in many applications ★ **Optional one or two %RH level alarm outputs:** Provide the user the ability to monitor whether the RH level has exceeded or fallen below pre-determined and critical levels within the application ★ **Multi-function ASIC:** Provides flexibility within the application by lowering or eliminating the risk and cost of OEM calibration ★ **Two configurations:** Increase flexibility of use; HIH6130: no filter, non-condensing; HIH6131: hydrophobic filter and condensation-resistant allow use in many condensing environments

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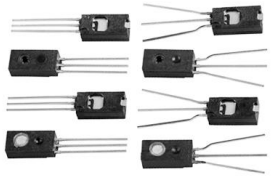
Table 6. Humidity Sensors (continued)

HIH-4000 Series	HIH-4020/4021 Series	HIH-4030/4031 Series	HIH-5030/5031 Series	HCH-1000 Series
				
Features and Benefits				
• Instrumentation-quality RH sensing performance in a competitively priced, solderable SIP • Accurate, fast response • Multilayer construction provides enhanced resistance to wetting, dirt, and common environmental chemicals • Laser trimmed for stable, low drift performance • Factory calibration data designed to provide individually-matched downstream electronics and accuracy • HIH-4020/4021 Series: Available covered/uncovered and filtered/unfiltered for application flexibility		• Multilayer construction designed to provide enhanced resistance to wetting, dirt, and common environmental chemicals. • Available covered, filtered/unfiltered for application flexibility • Surface mount design • Low current draw • Factory calibration data designed to provide individually-matched downstream electronics and accuracy. • Voltage supply: – HIH-4030/4031: 4 Vdc to 5.8 Vdc – HIH-5030/5031: 2.7 Vdc to 5.5 Vdc		• Unbuffered capacitive output for a cost-effective solution • Reduced temperature dependence • Low hysteresis • Long-term stability • Enhanced sensitivity/response

Flexible Heater Assembly

Moisture introduced into the air stream is generated by either mist or heated vapor. This is often best accomplished by heating water to a vapor and introducing it into the air stream. This method often has an advantage over the misting method as it creates vapor, as well as heat. These flexible heaters are custom-designed to customer requirements. On-board sensors such as thermistor thermal links and electrical fuses are commonly added. (See Table 7.)

Table 7. Flexible Heater Assembly

Custom Configurations	Features and Benefits
	• Flat, molded-to-shape, spiral wrap, transparent, and high-temperature configurations • Single, multiple or variable Watt densities designed to customize heat output • Variety of manufacturing materials, including silicone and other flexible dielectric components

Magnetic Sensor ICs

The durable SS400 Series is designed to provide enhanced output accuracy for smooth motor control that reduces noise and vibration in motor assembly fan systems.
Its 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 8.)

Table 8. Magnetic Sensor ICs

SS400 Series	Features and Benefits
	• Quad Hall-effect design minimizes effects of mechanical or thermal stress on output, and promotes a stable output • Unipolar, bipolar or bipolar latching magnetics and customizable operate/release points provide application flexibility • Negative compensation slope optimized to match negative temperature coefficient of lower-cost magnets, providing robust design over wide temperature range • Band gap regulation promotes stable operation over supply voltage range • Low power consumption enhances energy efficiency

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⚠ 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 application note 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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