

Sensors in Ventilators

An Application Note

Background

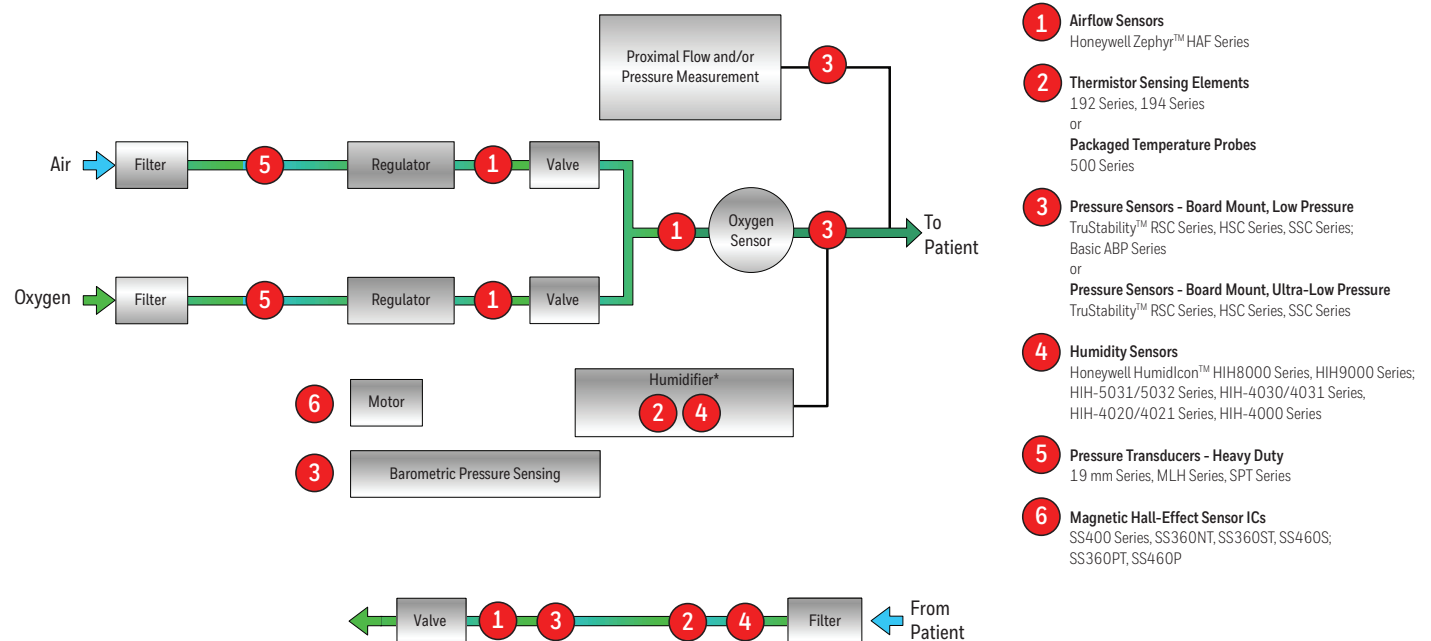
A medical ventilator is designed to move a mixture of air and oxygen into and out of the patient's lungs to either assist in breathing, or, in some cases, mechanically breathe for the patient who is breathing insufficiently or is physically unable to breathe.

Solutions

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



Figure 1. Potential Honeywell Sensors Used in Ventilators



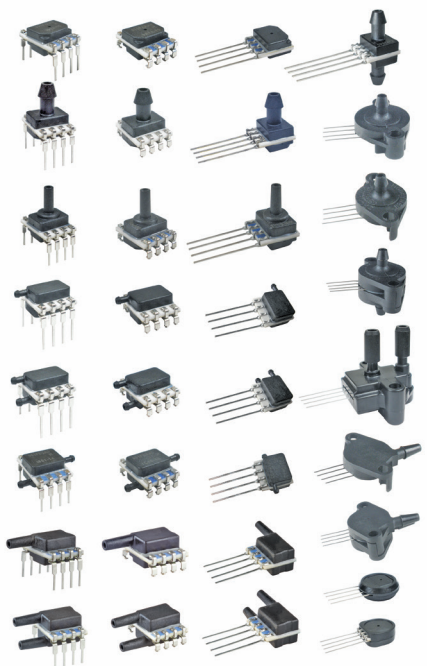
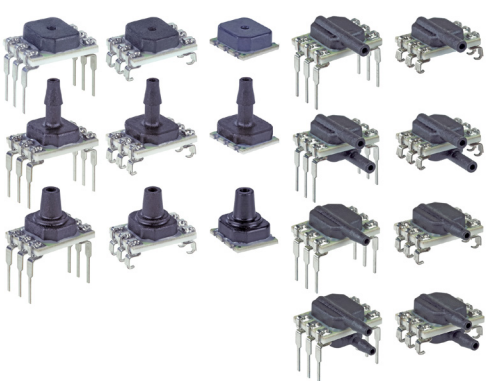
* Humidifier may be manufactured by a third party.

Pressure Sensors - Board Mount, Low and Ultra-Low

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

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 1.)

Table 1. Low and Ultra-Low Pressure Sensors

TRUSTABILITY™ RSC SERIES, HSC SERIES, SSC SERIES	FEATURES
	<ul style="list-style-type: none"> • 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 • Industry-leading accuracy: <ul style="list-style-type: none"> - RSC Series: $\pm 0.1\%$ FSS BFSL - HSC Series and SSC Series: $\pm 0.25\%$ FSS BFSL • Provides greater than 18 bits of real resolution (RSC Series) • Wide pressure range: ± 1.6 mbar to ± 10 bar ± 160 Pa to ± 1 MPa ± 0.5 inH₂O to ± 150 psi • Miniature package size • Extremely low power consumption • Temperature compensation and calibration provide an amplified signal • Digital ASIC output in either I²C 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 and customized calibration capabilities increase flexibility • REACH and RoHS compliant
BASIC ABP SERIES	FEATURES
	<ul style="list-style-type: none"> • Compensated, amplified • Industry-leading long-term stability ($\pm 0.25\%$ FSS) • Industry-leading accuracy ($\pm 0.25\%$ FSS BFSL) • Industry-leading flexibility • Total Error Band ($\pm 1.5\%$ FSS) • Wide pressure range: 60 mbar to 10 bar 6 kPa to 1 MPa 1 psi to 150 psi • High burst pressures • Energy efficient • Ratiometric analog; I²C- or SPI-compatible 14-bit digital output (min. 12-bit sensor resolution) • As small as 8 mm x 7 mm • REACH and RoHS compliant

Pressure Transducers - Heavy Duty

Customer Benefits: Accurate, easy to use, easy to design in, improves patient safety.

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 2.)

Table 2. Heavy Duty Pressure Transducers

19 MM SERIES	FEATURES
	<ul style="list-style-type: none"> • Low cost • Rugged, isolated stainless steel package • Small size • Reliable semiconductor technology • Calibrated and temperature compensated • Absolute and gage pressures • Vacuum compatible, isolated sensors • 0 psi to 3 psi to, 0 psi to 500 psi
MLH SERIES	FEATURES
	<ul style="list-style-type: none"> • All metal wetted parts for use in wide variety of fluid applications • No internal elastomeric seals mean no o-ring compatibility issues • Amplified outputs eliminate cost of external amplifiers • Input reverse voltage protection guards against mis-wiring • Less than 2 ms response time provides accurate, high speed measurement • Rated IP65 or better for protection from harsh environments
SPT SERIES	FEATURES
	<ul style="list-style-type: none"> • Reliable semiconductor technology • Calibrated and temperature compensated • Rugged, stainless steel package • NEMA 4 design • Small size • Absolute, gage, sealed gage, vacuum gage pressures • 0 psi to 3 psi, 0 psi to 5000 psi

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.)

Customer Benefits: Improves patient comfort, eases patient breathing, quiet, portable, reliable

Table 3. Airflow Sensors



HONEYWELL ZEPHYR™ ANALOG OR DIGITAL AIRFLOW SENSORS, HAF SERIES, ±50 SCCM TO ±750 SCCM	FEATURES
	<ul style="list-style-type: none"> • Total Error Band as low as ±0.25 %FSS allows for precise airflow measurement • Fast response time (1 ms) • Wide range of airflows: ±50, ±100 ±200, ±400 or ±750 SCCM, or custom flow ranges • Customizable flow ranges and configurable package styles • Full calibration and temperature compensation • Linear output • Low pressure drop typically improves patient comfort and reduces noise and system wear • 0.039% FS resolution (analog version) or high 12-bit resolution (digital version) increases ability to sense small airflow changes • Low 3.3 Vdc operating voltage option and low power consumption • ASIC-based I²C digital output (digital version) compatibility • Insensitivity to altitude • Small size • RoHS-compliant materials meet Directive 2002/95/EC

Table 3. Airflow Sensors (continued)

HONEYWELL ZEPHYR™ DIGITAL AIRFLOW SENSORS, HAF SERIES: 10 SLPM TO 300 SLPM	FEATURES
	<ul style="list-style-type: none"> • Industry's smallest Total Error Band allows for precise airflow measurement • High accuracy • Fast response time (1 ms) • High stability • High sensitivity at very low flows • High 12-bit resolution • 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 • Choice of port styles • Linear output • Wide supply voltage range (3 Vdc to 10 Vdc) • ASIC-based I²C digital output • Factory or custom calibration for multiple gas types • RoHS-compliant materials meet Directive 2002/95/EC



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 4.)

Customer Benefits: Flexible, cost effective, small


Table 4. Thermistor Sensing Elements

192 SERIES	FEATURES
	<ul style="list-style-type: none"> • Bare leads (192 Series) or insulated leads (194 Series) • 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
<p>194 SERIES</p> 	

Packaged Temperature Probes

These products may perform the same function as the Thermistor Sensing Elements. (See Table 5.)

Table 5. Packaged Temperature Probes

500 SERIES	FEATURES
	<ul style="list-style-type: none"> • 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.)

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

Table 6. Humidity Sensors

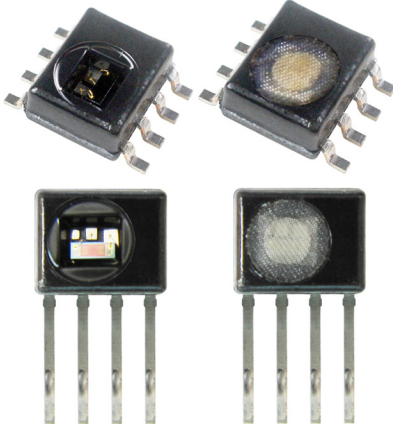


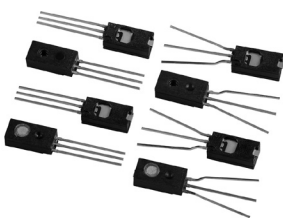
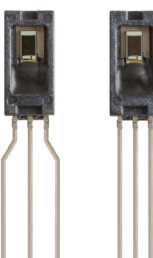
HIH8000 SERIES, HIH9000 SERIES	FEATURES
	<ul style="list-style-type: none"> • Industry-leading long term stability (1.2 %RH over five years) • Industry-leading reliability (MTTF 9,312,507 HR) • Lowest total cost solution due to being an industry leading combined humidity/temperature sensor • Low supply voltage and low power consumption • High 14-bit humidity sensor resolution and 14 bit temperature sensor resolution • True, temperature-compensated digital I²C or SPI output • SOIC-8 SMD (Surface Mount Device) or SIP 4 Pin • Ultra small size • Available with hydrophobic filter and condensation-resistance • Tape and reel allows for use in high volume, automated pick-and-place manufacturing • Wide operating temperature range of -40 °C to 125 °C [-40 °F to 257 °F] • Optional one or two %RH level alarm outputs • Multi-function ASIC • RoHS and WEEE compliant, halogen-free

Table 6. Humidity Sensors (continued)

HIH-5030/5031 SERIES	FEATURES
	<ul style="list-style-type: none"> • 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
<p>HIH-4030/4031 SERIES</p> 	<ul style="list-style-type: none"> • Voltage supply: <ul style="list-style-type: none"> - HIH-5030/5031: 2.7 Vdc to 5.5 Vdc - HIH-4030/4031: 4 Vdc to 5.8 Vdc
<p>HIH-4020/4021 SERIES</p> 	<p>FEATURES</p> <ul style="list-style-type: none"> • 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
<p>HIH-4000 SERIES</p> 	<ul style="list-style-type: none"> • HIH-4020/4021 Series: Available covered uncovered and filtered/unfiltered

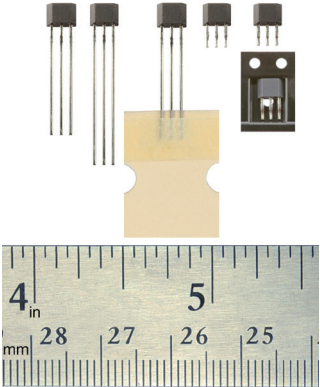
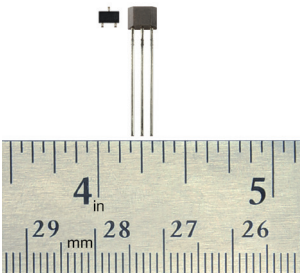
Hall-effect Magnetic Sensor ICs

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"> • 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 • 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
S360NT, S360ST, SS460S; SS360PT, SS460P	FEATURES
	<ul style="list-style-type: none"> • Fastest response time in its class • No chopper stabilization • High sensitivity • Latching magnetics • Built-in reverse voltage • Durable design • RoHS-compliant material meets Directive 2002/95

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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