Application Note
Sensors and Flexible Heaters in Anesthesia Machine Applications

Background

A medical anesthesia machine is designed to deliver drugs that help to eliminate pain and other unwanted sensations.
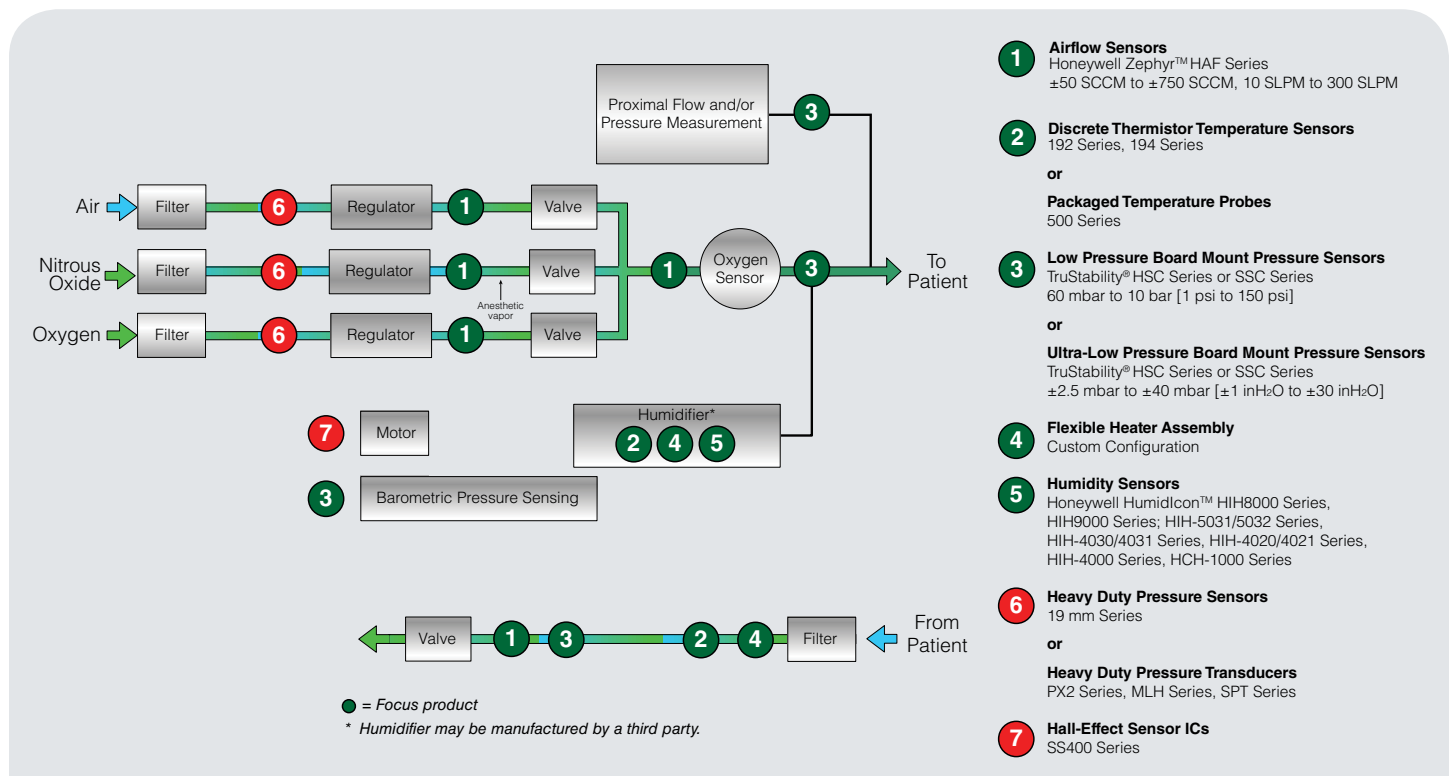
The continouous flow anesthetic machine provides an accurate and constant supply of medical gases (such as air, oxygen and nitrous oxide) mixed with an accurate conventration of anesthetic vapor (such as isoflurane), and delivers this mixture to the patient at a desired pressure and flow.

Solutions

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

Anesthesia machine

Potential Honeywell products used in anesthesia machines

1 Airflow Sensors
Honeywell Zephyr™ HAF Series
±50 SCCM to ±750 SCCM, 10 SLPM to 300 SLPM

2 Discrete Thermistor Temperature Sensors
192 Series, 194 Series

or

Packaged Temperature Probes
500 Series

3 Low Pressure Board Mount Pressure Sensors
TruStability® HSC Series or SSC Series
60 mbar to 10 bar [1 psi to 150 psi]

or

Ultra-Low Pressure Board Mount Pressure Sensors
TruStability® HSC Series or SSC Series
±2.5 mbar to ±40 mbar [±1 inH$_2$O to ±30 inH$_2$O]

4 Flexible Heater Assembly
Custom Configuration

5 Humidity Sensors
Honeywell HumidIcon™ HIH8000 Series,
HIH9000 Series; HIH-5031/5032 Series,
HIH-4030/4031 Series, HIH-4020/4021 Series,
HIH-4000 Series, HCH-1000 Series

6 Heavy Duty Pressure Sensors
19 mm Series

or

Heavy Duty Pressure Transducers
PX2 Series, MLH Series, SPT Series

7 Hall-Effect Sensor ICs
SS400 Series

● = Focus product
* Humidifier may be manufactured by a third party.

Sensing and Control

Application Note
Sensors and Flexible Heaters in Anesthesia Machine Applications

PRESSURE SENSORS

Low Pressure Board Mount and **Ultra-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.

TruStability® Board Mount Pressure Sensors
(HSC Series and SSC Series)
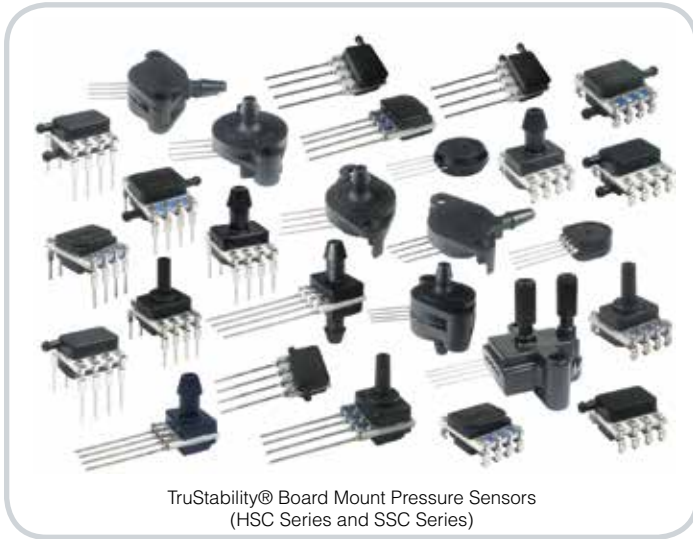
Features and Benefits

- 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

Heavy Duty Pressure Sensors and **Heavy Duty Pressure Transducers**: PX2 Series, MLH 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.

19 mm Series

PX2 Series

MLH 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

Application Note
Sensors and Flexible Heaters in Anesthesia Machine Applications

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.

Honeywell Zephyr™ Analog or Digital Airflow Sensors (HAF Series)
±50 SCCM to ±750 SCCM

Features and Benefits (★ = competitive differentiator)

★ Total Error Band (TEB) as low as ±0.25 %FSS allows for precise airflow measurement, often ideal for demanding applications with high accuracy requirements
Wide range of airflows:

★ Fast response time allows a customer's application to respond quickly to airflow change, important in critical medical (e.g., anesthesia) and industrial (e.g., fume hood) applications

★ Wide range of airflows: Zephyr measures mass flow at standard flow ranges of ±50, ±100 ±200, ±400 or ±750 SCCM, or custom flow ranges, increasing the options for integrating the sensor into the application

★ Customizable flow ranges and configurable package styles to meet specific end-user needs

• Full calibration and temperature compensation typically allow the customer to remove additional components associated with signal conditioning from the PCB, reducing PCB size as well as costs often associated with those components (e.g., acquisition, inventory, assembly)

• High sensitivity at very low flows provides for faster response time at the onset or cessation of flow

★ Linear output provides more intuitive sensor signal than the raw output of basic airflow sensors, which can help reduce production costs, design, and implementation time

★ High stability reduces errors due to thermal effects and null shift to provide accurate readings over time, often eliminating need for system calibration after PCB mount and periodically over time

★ Low pressure drop typically improves patient comfort in medical applications, and reduces noise and system wear on other components such as motors and pumps

• 0.039 %FS resolution (analog version) or high 12-bit resolution (digital version) increases ability to sense small airflow changes, allowing customers to more precisely control their application

• Low 3.3 Vdc operating voltage option and low power consumption allow for use in battery-driven and other portable applications

• ASIC-based I²C digital output (digital version) compatibility eases integration to microprocessors or microcontollers, reducing PCB complexity and component count.

• Insensitivity to mounting orientation allows customer to position sensor in most optimal point in the system, eliminating concern for positional effects

• Insensitivity to altitude eliminates customer-implemented altitude adjustments in the system, easing integration and reducing production costs by not having to purchase additional sensors for altitude adjustments

• Small size occupies less space on PCB, allowing easier fit and potentially reducing production costs; PCB size may also be reduced for easier fit

• RoHS-compliant materials meet Directive 2002/95/EC

Honeywell Zephyr™ Digital Airflow Sensors (HAF Series)
10 SLPM to 300 SLPM

Features and Benefits (★ = competitive differentiator)

★ Industry's smallest Total Error Band (TEB) allows for precise airflow measurement, often ideal for demanding applications with high accuracy requirements

• High accuracy is ideal for use in demanding applications

• Fast response time allows the customer's application to respond quickly to airflow change, 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 to provide accurate readings over time and often

Application Note
# Sensors and Flexible Heaters in Anesthesia Machine Applications

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 onet of 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 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, increasing the options for integrating 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: flexible regulated power circuit (3 Vdc to 10 Vdc) gives the designer the flexibility to choose the supply voltage that works best in the system
- ASIC-based I^{2}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 many gases, such as dry air, helium (He), argon (Ar), nitrogen (N_2), nitrous oxide (N_2O), and carbon dioxide (CO_2), or custom calibrated for the end customer, eliminating the need to implement gas correction factors
- RoHS-compliant materials meet Directive 2002/95/EC

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.

192 Series
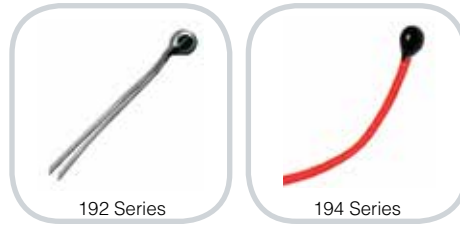
194 Series

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

PACKAGED TEMPERATURE PROBES

These products may perform the same function as the Discrete Thermistor Temperature Sensors.

500 Series

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.

Application Note
Sensors and Flexible Heaters in Anesthesia Machine Applications

HIH8000 Series
HIH9000 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
  - Eliminates the need to regularly recalibrate the sensor in the application, which can be inconvenient and costly

★ Industry-leading reliability (MTTF 9,312,507 HR): Thermoset-polymer capacitive sensing element's multilayer construction provides resistance to most application hazards such as condensation, dust, dirt, oil, and common environmental chemicals, which help provide industry-leading reliability.

★ Lowest total cost solution: Delivers the lowest total cost solution due to the sensor's industry-leading combined humidity/temperature sensor

• Combined humidity and temperature sensor: Allows the RH measurement to be temperature compensated, and provides a second, standalone temperature sensor output; allows the user to purchase one sensor instead of two

★ Energy efficient:
  - Low supply voltage: Can operate down to 2.3 Vdc, which allows use in low energy and wireless-compatible applications to enhance energy savings and prolong system battery life
  - Low power consumption: The sensor goes into sleep mode when not taking a measurement within the application, consuming only 1 µA versus 650 µA in full operation in a battery operated system; sleep mode helps maximize battery life, reduces power supply size, and reduces the application's overall weight

• 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 relative humidity or temperature change

★ True, temperature-compensated digital I²C or SPI output: Typically allows the customer to remove the components associated with signal conditioning from the PCB to free up space and reduce costs associated with those components (e.g., acquisition, inventory, assembly). True, temperature-compensated digital I²C or SPI output often eliminates problems that could occur from having multiple signal conditioning components across the PCB, as well as simplifies integration to the microprocessor, eliminating the need for customer-implemented, complex signal conditioning.

★ Housing style: SOIC-8 SMD (Surface Mount Device) or SIP 4 Pin; ultra small size allows for flexibility of use within the application, occupies less space on the PCB, and typically simplifies placement on crowded PCBs or in small devices; industry standard design simplifies design-in

• Filter: Available with hydrophobic filter and condensation-resistance, allowing for use in many condensing environments, or without hydrophobic filter, non-condensing

• Tape and reel: 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

• Wide operating temperature range: -40 °C to 125 °C [-40 °F to 257 °F] allows for use in many applications

• Optional one or two %RH level alarm outputs: Provides the ability to monitor whether the RH level has exceeded or fallen below pre-determined and critical levels within the application

• Multi-function ASIC: Delivers flexibility within the application by lowering or eliminating the risk and cost of OEM calibration

• RoHS and WEEE compliant, halogen-free

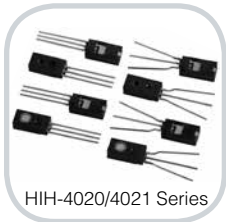HIH-5030/5031 Series   HIH-4030/4031 Series

Features and Benefits
• 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-

Application Note
Sensors and Flexible Heaters in Anesthesia Machine Applications

matched downstream electronics and accuracy.
- Voltage supply:
  - HIH-5030/5031: 2.7 Vdc to 5.5 Vdc
  - HIH-4030/4031: 4 Vdc to 5.8 Vdc

HIH-4020/4021 Series   HIH-4000 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

HCH-1000 Series

Features and Benefits
- 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.
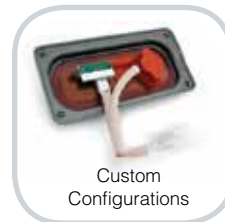
Custom Configurations

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

HALL-EFFECT 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.

Application Note

Sensors and Flexible Heaters in Anesthesia Machine Applications

SS400 Series
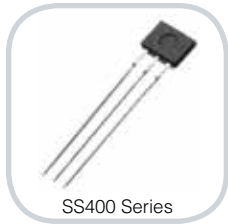
Features and Benefits

- 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

Find out more

To learn more about Honeywell's sensing and control products, call **1-800-537-6945**, visit **sensing.honeywell.com,** or e-mail inquiries to **info.sc@honeywell.com**