

# Sensors in Hemodialysis Machines

## An Application Note

### Background

Hemodialysis machine treatments replace some kidney functions by removing waste and fluid from the bloodstream via diffusion and osmosis of solutes and fluid across a semipermeable dialysis membrane.

Blood in one compartment is pumped along one side of the membrane while a dialysate (a crystalloid solution that acts as a sponge for impurities) is pumped along the other side, in a separate compartment, in the opposite direction.

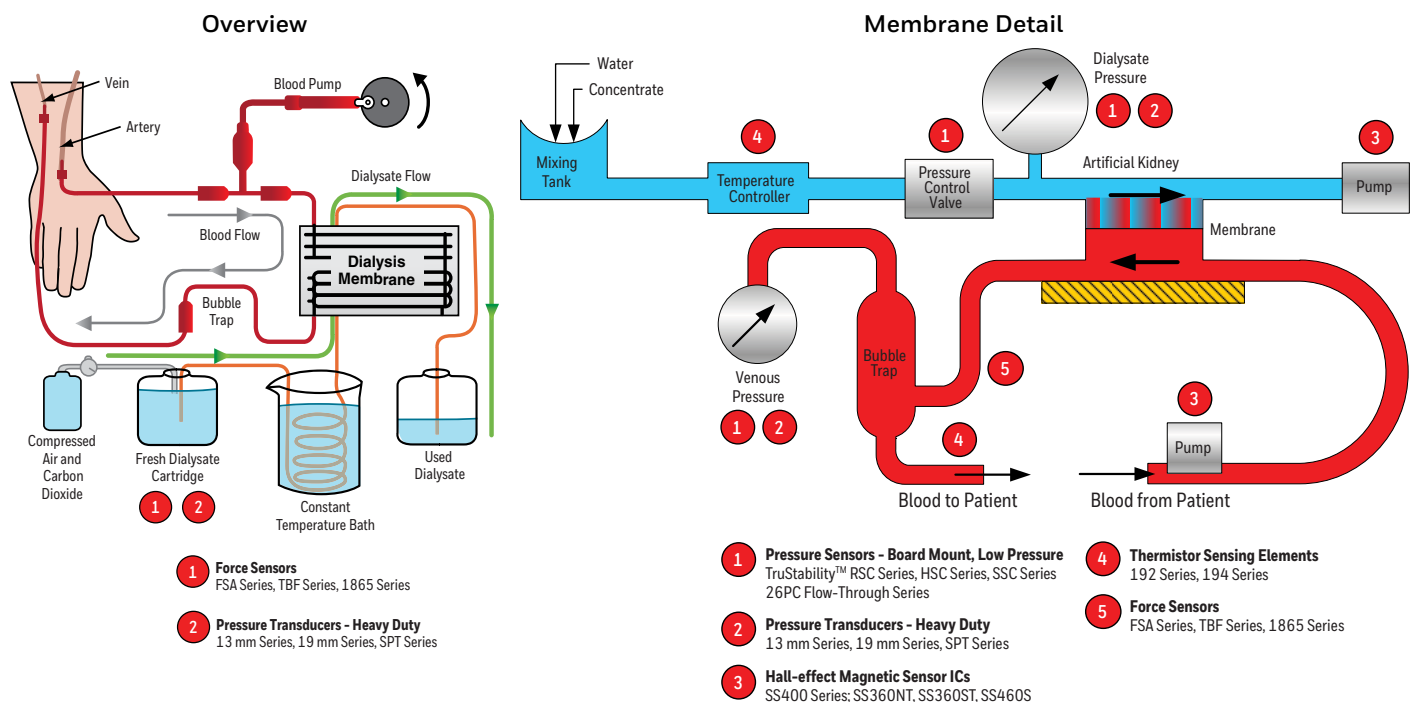
Ultrafiltration occurs by increasing the hydrostatic pressure across the membrane by applying a negative pressure to the dialysate compartment of the dialyzer. This pressure gradient causes water and dissolved solutes to move from the blood to the dialysate. The cleansed blood returns via the circuit back to the body.



### Solution

Honeywell manufactures many sensors that may be used in hemodialysis machines. They provide dialysate cartridge presence/absence detection, fluid pressure/flow and temperature measurement, and output for smooth motor control. (See Figure 1.)

Figure 1. Hemodialysis Overview and Membrane Detail Showing Potential Honeywell Products Used



## Force Sensors

The flexible silicone membrane interface may be used to detect the presence or absence of a fresh dialysate cartridge to ensure its presence before the machine is used. These sensors are used in a non-invasive

manner and require no disinfection or sterilization before reuse. (See Table 1.)

**Customer Benefits:** Reliable, sensitive, stable

**Table 1. Force Sensors**

FSA SERIES	FEATURES
	<ul style="list-style-type: none"> <li>• Wide variety of force ranges:               <ul style="list-style-type: none"> <li>- Newton (N): 5, 7.5, 10, 15, 20, 25</li> <li>- pound (lb): 1, 1.5, 2, 3, 5</li> <li>- gram (g): 500, 750</li> <li>- kilogram (kg): 1, 2</li> </ul> </li> <li>• Total Error Band of <math>\pm 5\%</math>FSS</li> <li>• Accuracy of <math>\pm 3\%</math>FSS</li> <li>• Ratiometric analog, or SPI- or I<sup>2</sup>C compatible digital output</li> <li>• Fully calibrated and temperature compensated over a temperature range of 5 °C to 50 °C [41 °F to 122 °F]</li> <li>• Overforce of 15 lb [6804 g]</li> <li>• Supply voltage of 3.3 Vdc typ. or 5.0 Vdc typ.</li> <li>• Low power consumption of 13 mW (analog) or 20 mW (digital)</li> <li>• Excellent part-to-part repeatability</li> <li>• Enhanced reliability</li> <li>• Stable interface plunger</li> <li>• Internal diagnostic functions available</li> <li>• REACH and RoHS compliant</li> </ul>
TBF SERIES BASIC	FEATURES
	<ul style="list-style-type: none"> <li>• Solid state, piezoresistive, gage pressure transducer mounted in a plastic package; special silicone gel transmits applied pressure to a silicon piezoresistive MEMS die mounted on a robust ceramic substrate</li> <li>• For applications where force is applied by a flexible membrane to the sensor, such as infusion pumps, the precision height silicone diaphragm provides long life and is a reliable replacement for older force or load cell transducers</li> <li>• Silicone rubber diaphragm allows compatibility with some liquid media applications</li> <li>• Smallest package size in its class (7 mm x 7 mm x 3,89 mm)</li> <li>• Wide pressure range of 1 bar to 10 bar   100 kPa to 1 MPa   15 psi to 150 psi</li> <li>• Tight accuracy specification of <math>\pm 0.15\%</math>FSS</li> <li>• Wide operating temperature range of -20 °C to 85 °C [-4 °F to 185 °F]</li> <li>• Low power consumption</li> <li>• Stable offset voltage</li> <li>• Not sensitive to mounting orientation</li> <li>• RoHS2 compliance</li> </ul>
1865 SERIES	FEATURES
	<ul style="list-style-type: none"> <li>• Silicon pressure/force interface diaphragm</li> <li>• Pressure measurement for liquid media</li> <li>• Medical-grade materials</li> <li>• 8-pin DIP electrical connection</li> <li>• Choice of voltage or constant current excitation</li> <li>• Temperature compensated</li> <li>• Enhanced performance</li> <li>• Reliable replacement for older force or load cell transducers</li> <li>• Silicone rubber diaphragm allows potential compatibility with liquid media applications</li> <li>• Laser-trimmed compensation may be specified to operate with a constant current or voltage supply</li> </ul>

**Pressure Sensors - Board Mount, Low Pressure**

Honeywell's TruStability™ (RSC Series, HSC Series and SCC Series) and the 26PC Flow-Through Series are designed to provide enhanced reliability and may be used to obtain a direct, in-line continuous dialysate and venous pressure measurement in the dialysis membrane without interrupting flow. The easy-to-sterilize package eliminates the need for an additional pressure tap and/or manifold, minimizing the unused space

in the flow measurement path, which helps to prevent bacteria contamination and simplifies sterilization. (See Table 2.)

**Customer Benefits:** Stable, accurate, reliable, efficient, sensitive

**Table 2. Pressure Sensors - Board Mount, Low Pressure**

TRUSTABILITY™ RSC SERIES, HSC SERIES, SSC SERIES	FEATURES
	<ul style="list-style-type: none"> <li>• 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</li> <li>• Industry-leading stability often eliminates need for calibration after PCB mount, and periodically over time</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 combine with customized calibration capabilities increases application flexibility</li> <li>• RSC Series provides high 24-bit resolution and Total Error Band as low as 0.25 %FSS</li> </ul>
26PC FLOW-THROUGH SERIES	FEATURES
	<ul style="list-style-type: none"> <li>• Flow through design in miniature, plastic package (versus stainless steel package) designed to provide a reduced-cost alternative</li> <li>• Integrated flow through design eliminates need for many additional connections and parts</li> <li>• Enhanced reliability due to fewer connections and parts</li> <li>• Robust media compatibility requires no gel coating</li> <li>• Calibrated and temperature compensated with true wet/wet differential sensing for increased application flexibility</li> </ul>

**Pressure Transducers - Heavy Duty**

The 13 mm Series, 19 mm Series and SPT Series, when located in a fresh dialysate cartridge, may be used to monitor pressure in the flexible tubing that carries blood or dialysate to provide continuous feedback of line pressures and pump control. These products may also be used to perform the same function as the TruStability™ and the 26PC Flow-Through Series in the dialysis membrane. (See Table 3.)

**Customer Benefits:** Small, stable, low current consumption, stainless steel package, enhanced performance

**Table 3. Pressure Transducers - Heavy Duty**

13 MM SERIES AND 19 MM SERIES	FEATURES
	<ul style="list-style-type: none"> <li>• Small size for use on portable equipment</li> <li>• High impedance and low current draw for battery operation</li> <li>• Constant current for use with 4 mA to 20 mA amplifier integrated circuits</li> <li>• Oil-free isolated sensor reduces risk of leakage and contamination</li> <li>• Flush mount, non-corrugated diaphragm for easy sanitation</li> <li>• Stainless steel package for easy disinfection</li> <li>• Calibrated and temperature compensated for enhanced performance</li> </ul>
SPT SERIES	

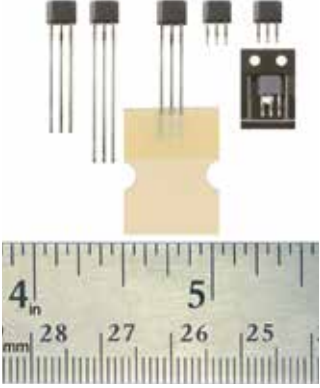
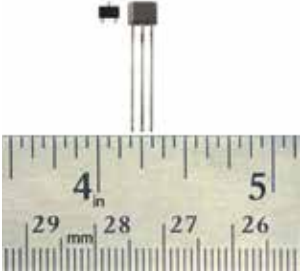
### Hall-effect Magnetic Sensor ICs

The durable SS400 Series is designed to provide enhanced output accuracy for smooth motor control that reduces noise and vibration. 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 4.)

**Customer Benefits:** Quiet, cost-effective, energy-efficient

**Table 4. Hall-effect Magnetic Sensor ICs**

SS400 SERIES	FEATURES
 <p>The image shows five SS400 Series Hall-effect Magnetic Sensor ICs. Four are shown as individual components with three leads each, and one is shown in a larger, yellow-tinted perspective view. A ruler below the components shows measurements in inches (4 to 5) and millimeters (25 to 28).</p>	<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	FEATURES
 <p>The image shows two S360NT, S360ST, or SS460S Hall-effect Magnetic Sensor ICs. One is shown as a small component with three leads, and the other is shown in a larger, black-tinted perspective view. A ruler below the components shows measurements in inches (4 to 5) and millimeters (26 to 29).</p>	<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>


### Thermistor Sensing Elements

Temperature directly affects the permeation rate across the dialysis membrane. The 192 Series and 194 Series provide temperature measurement for enhanced control of this variable. The sensor is coupled to a microcontroller designed to monitor the temperature of the operation and to interact with the controller to help regulate the temperature of the system. (See Table 5.)

Honeywell offers several configurations. These packaged sensors are available as discrete components for custom-built assemblies, as well as full assembly solutions that the customer may simply pigtail into the system.

**Customer Benefits:** Application flexibility, cost-effective, small

**Table 5. Thermistor Sensing Elements**

192 SERIES, 194 SERIES	FEATURES
 <p>The image shows two thermistor sensing elements. On the left is a 192 Series element with bare leads, and on the right is a 194 Series element with insulated leads. Both have a small sensing head at the end of a wire.</p>	<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>

## **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.**

While Honeywell may provide application assistance personally, through our literature and the Honeywell web site, it is buyer's sole responsibility 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 writing. However, Honeywell assumes no responsibility for its use.

## **For more information**

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