

Sensors and Flexible Heaters in Hemodialysis Machine Applications

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. (See Figures 1 and 2.)

SOLUTIONS

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 Figures 2 and 3.)

Figure 1. Hemodialysis Machine in Use



Figure 2. Hemodialysis Overview Showing Potential Honeywell Products Used

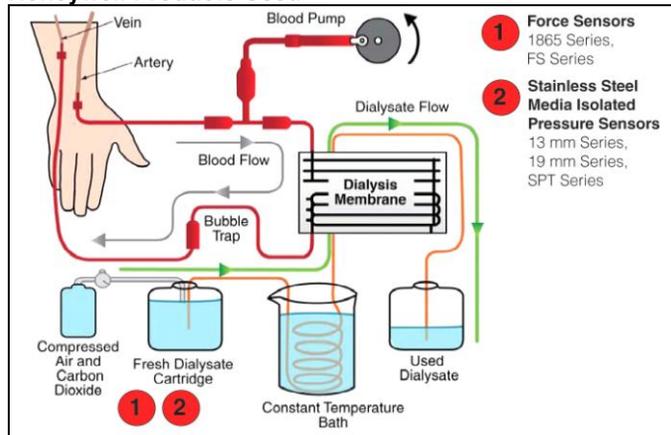
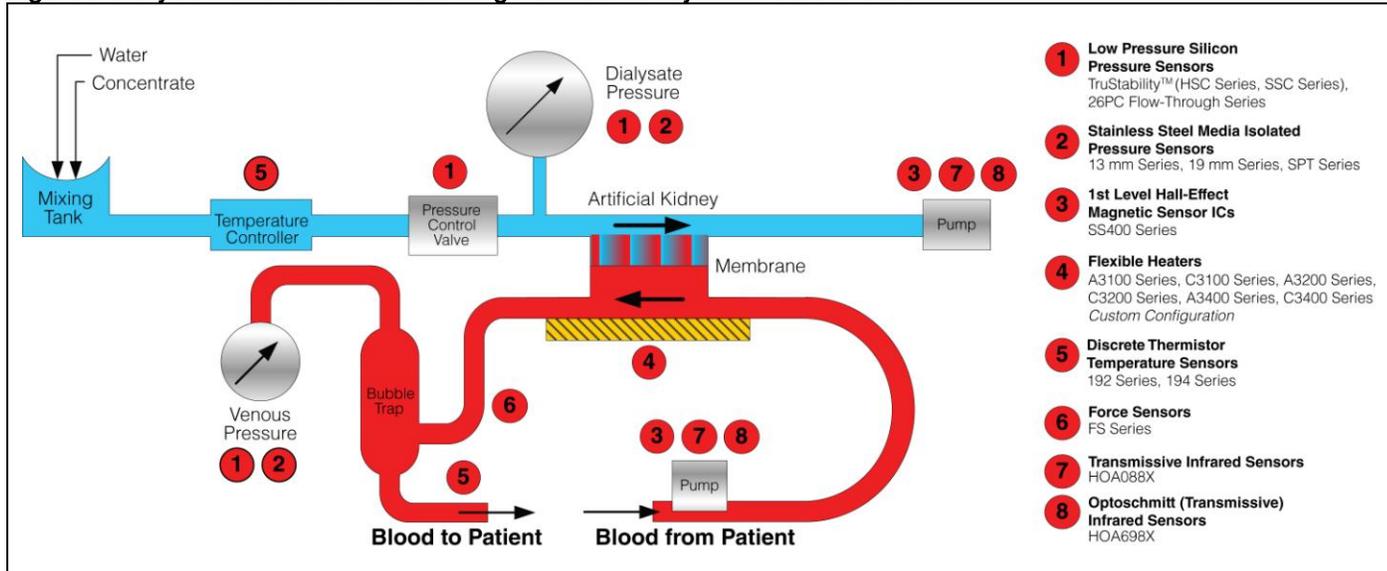


Figure 3. Dialysis Membrane Detail Showing Potential Honeywell Products Used



Sensors in Hemodialysis Machine Applications

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.)

Table 1. Force Sensors

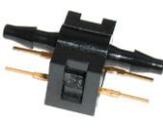
1865 Series	FS Series
	
Features and Benefits	
<ul style="list-style-type: none"> • Large sensing area reduces cartridge misalignment errors • Repeatable output provides clear indication of cartridge presence/absence • Temperature compensation reduces temperature variation errors • Enhanced response eliminates equipment start-up delay • Silicone rubber diaphragm allows compatibility with many liquid media applications 	<ul style="list-style-type: none"> • Silicone sensing area tolerates occasional liquid splash as well as cleaning with soap and water • Different pressure ranges simplify equipment design • Calibrated and temperature compensated for enhanced accuracy and stability • Small size allows multiple sensors in confined spaces • Robust package designed to promote corrosion resistance and isolation to external package stress

Pressure Sensors

Low Pressure Silicon: Honeywell's TruStability™ (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.)

Stainless Steel Media Isolated: 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 sensors may also be used to perform the same function as the TruStability™ and the 26PC Flow-Through Series in the dialysis membrane. (See Table 2.)

Table 2. Pressure Sensors

Low Pressure Silicon		Stainless Steel Media Isolated
TruStability™ (HSC Series and SCC Series)	26PC Flow-Through Series	13 mm Series, 19 mm Series, SPT Series
		
Features and Benefits		
<ul style="list-style-type: none"> • 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 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 combine with customized calibration capabilities increases application flexibility 	<ul style="list-style-type: none"> • Flow through design in miniature, plastic package (versus stainless steel package) designed to provide a reduced-cost alternative • Integrated flow through design eliminates need for many additional connections and parts • Enhanced reliability due to fewer connections and parts • Robust media compatibility requires no gel coating • Calibrated and temperature compensated with true wet/wet differential sensing for increased application flexibility 	<ul style="list-style-type: none"> • Small size for use on portable equipment • High impedance and low current draw for battery operation • Constant current for use with 4 mA to 20 mA amplifier integrated circuits • Oil-free isolated sensor reduces risk of leakage and contamination • Flush mount, non-corrugated diaphragm for easy sanitation • Stainless steel package for easy disinfection • Calibrated and temperature compensated for enhanced performance

Sensors in Hemodialysis Machine Applications

1st Level Hall-Effect Magnetic Position Sensor ICs

The robust and 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 3.)

Table 3. 1st Level Hall-Effect Magnetic Position Sensor ICs

SS400 Series	Features and Benefits
	<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 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

Flexible Heaters

Honeywell's flexible heaters are designed to provide controlled heat for blood or dialysate warming to body temperature prior to re-entry into the body. This may be accomplished by either heat exchange constant temperature bath) or direct heat

through warming plates. These flexible heaters are custom-designed to customer requirements. Other components, such as NTC thermistors, RTDs or solid state temperature sensors, may be added for temperature monitoring and control. (See Table 4.)

Table 4. Flexible Heaters

A3100 Series, C3100 Series, A3200 Series, C3200 Series, A3400 Series, C3400 Series	Features and Benefits
	<p>Although no standard product is available for this custom application, Honeywell offers a variety of material sets in heating elements, as well as insulation, to meet our customers' needs</p>

Discrete Thermistor Temperature Sensors

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. Honeywell offers several configurations. These packaged sensors are available as discreet components for custom-built assemblies, as well as full assembly solutions that the customer may simply pigtail into the system. (See Table 5.)

Table 5. Discrete Thermistors

192 Series, 194 Series	Features and Benefits
	<ul style="list-style-type: none"> • Bare leads (192 Series) or insulated leads (194 Series) designed for improved application flexibility • Resistance temperature 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

Sensors in Hemodialysis Machine Applications

Infrared Sensors

These sensors are designed to be used with an encoder wheel on the pump shaft to count shaft rotation. They contain an infrared emitter and a photosensor that are mounted facing

each other. Detection occurs when an opaque object passes through the package slot, interrupting the infrared path. (See Table 6.)

Table 6. Infrared Sensors

HOA088X Transmissive Sensors	HOA698X Optoschmitt (Transmissive) Sensors
	
Features and Benefits	
<ul style="list-style-type: none"> • Analog output • Variety of package styles and mounting options 	<ul style="list-style-type: none"> • Digital output • Variety of package styles and mounting options

⚠ 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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