SENSORS IN INFUSION PUMPS

Application Note

This application note reviews the many products Honeywell manufactures which may be used in infusion pumps (see Figure 1). These products are designed to provide occlusion detection, monitor fluid flow, provide output for smooth motor control, and support the identification and delivery process.

INTRODUCTION

An infusion pump, typically a screw pump that pushes on a syringe or cartridge, is used to deliver small amounts of medication to a patient intravenously

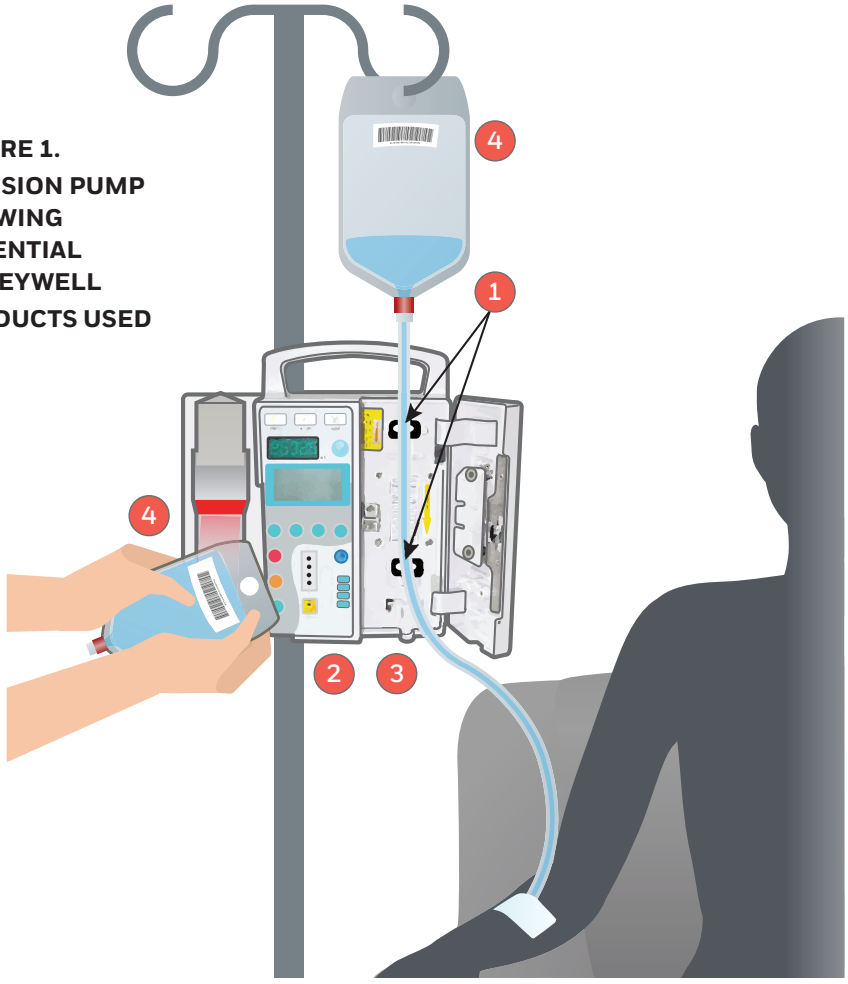


FIGURE 1. INFUSION PUMP SHOWING POTENTIAL HONEYWELL PRODUCTS USED

1. **Force Sensors**
   MicroForce FMA Series, FSA Series, FSG Series, FSS Series, FSS-SMT Series, TBF Series, 1865 Series
2. **Pressure Sensors - Board Mount**
   TruStability™ RSC Series, HSC Series, SSC Series; 26PC Flow-Through Series
3. **Magnetic Position Sensor ICs**
   Hall-Effect: SS490 Series; SS360NT, SS360ST, SS460S; Micropower SL353 Series
   or
   Magnetoresistive: Nanopower Series
4. **2D Scan Engines**
   N660X Series

Honeywell

FORCE SENSORS

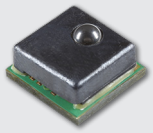
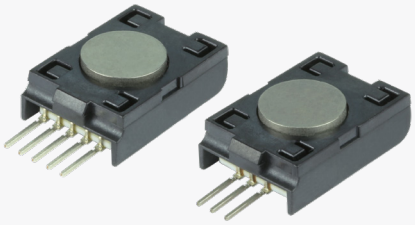
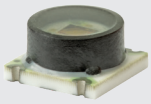
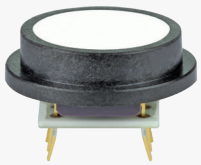
MicroForce FMA Series, FSA Series, TBF Series, 1865 Series

These force sensors (see Table 1) may be used to detect the presence or absence of a fresh dialysate cartridge before the dialysis machine can be used. They are used in a non-invasive manner and require no disinfection or sterilization before reuse. Other potential uses for Honeywell's force sensors include monitoring the flexible tubing pressure of the dialysate to detect whether the pressure exceeds a specified level, and monitoring the weight of the dialysate to detect whether there is a sufficient amount of dialysate in the fresh dialysate cartridge.

Benefits to Customer

- **Reliable:** Enhanced quality and reliability (<100 ppm).
- **Sensitive:** Enhanced sensitivity to force changes enables early detection of occlusion, enhancing patient safety.
- **Stable:** Ability to detect occlusion accurately over time provides enhanced stability and low drift.

TABLE 1. FORCE SENSORS

MICROFORCE FMA SERIES	FEATURES	
	• Small form factor: 5 mm x 5 mm [0.20 in x 0.20 in] • Accuracy: ±2 %FSS typical • SPI- or I²C-compatible digital output • Fully calibrated and temperature compensated over a temperature range of 5°C to 50°C [41°F to 122°F] • Available in a wide variety of standard and configurable force ranges	• Overforce: 3X force range • Supply voltage: 3.3 Vdc typ. or 5.0 Vdc typ. • Low power consumption: 14 mW • Enhanced part-to-part repeatability • Enhanced reliability • Stable, stainless steel sphere interface • Internal diagnostic functions available • REACH and RoHS compliant
FSA SERIES	**FEATURES**	
	• Wide variety of force ranges: - Newton (N): 5, 7.5, 10, 15, 20, 25 - pound (lb): 1, 1.5, 2, 3, 5 - gram (g): 500, 750 - kilogram (kg): 1, 2 • Total Error Band: ±5 %FSS • Accuracy: ±3 %FSS • Ratiometric analog or SPI- or I²C-compatible digital output • Fully calibrated and temperature compensated over a temperature range of 5°C to 50°C [41°F to 122°F]	• Overforce: 15 lb [6804 g] • Supply voltage: 3.3 Vdc typ. or 5.0 Vdc typ. • Low power consumption: 13 mW (analog) or 20 mW (digital) • Excellent part-to-part repeatability • Enhanced reliability • Stable interface plunger • Internal diagnostic functions available • REACH and RoHS compliant
TBF SERIES BASIC	**FEATURES**	
	• 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 • 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 • Silicone rubber diaphragm allows compatibility with some liquid media applications	• Small footprint (7 mm x 7 mm x 3,89 mm) • Wide pressure range: 1 bar to 10 bar | 100 kPa to 1 MPa | 15 psi to 150 psi • Tight accuracy specification: ±0.15 %FSS • Wide operating temperature range: -20°C to 85°C [-4°F to 185°F] • Low power consumption • Stable offset voltage • Not sensitive to mounting orientation • RoHS2 compliance
1865 SERIES	**FEATURES**	
	• Silicon pressure/force interface diaphragm • Pressure measurement for liquid media • Medical-grade materials • 8-pin DIP electrical connection • Choice of voltage or constant current excitation • Temperature compensated • Enhanced performance	• Reliable replacement for older force or load cell transducers • Silicone rubber diaphragm allows potential compatibility with liquid media applications • Laser-trimmed compensation may be specified to operate with a constant current or voltage supply

PRESSURE SENSORS AND TRANSDUCERS

Board Mount Pressure Sensors: TruStability™ RSC Series, HSC Series, SSC Series; 26PC Flow-Through Series (26PCFEP5G40)
Heavy Duty Pressure Transducers: 13 mm Series, 19 mm Series, SPT Series

Honeywell's TruStability and 26PC Series flow-through board mount pressure sensors (see Table 2) 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.

The 13 mm Series, 19 mm Series, and SPT Series heavy duty pressure transducers (see Table 3), 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 26PC Flow-Through Series in the dialysis membrane.

Benefits to Customer

- **Accurate:** Provides stable performance with low drift over time, allowing accurate pressure monitoring of fluid and blood flow to help maintain the pressure in the desired range, improving treatment efficiency and reducing the time it takes to remove fluid from the peritoneum.
  - TruStability sensors' accuracy is a result of precise manufacturing processes and temperature compensation and calibration. The RSC Series provides high 24-bit resolution and the Total Error Band after auto zero is as low as ±0.25 %FSS. The Total Error Band of the HSC Series and SSC Series depends on the pressure range, with the HSC Series as low as ±1 %FSS and the SSC Series as low as ±2 %FSS.
  - The 26PC Flow-Through Series offers accuracy of ±2 %FSS; the 13 mm Series, 19 mm Series, and SPT Series offer accuracy of 0.25 %FSS.
- **Easy to design in:** Customization with desired pressure ranges, connections, calibration, and temperature compensation minimizes customer's design-in effort.
- **Extended life:** Product availability throughout the customer's product life cycle minimizes the need to repeat the design-in process and requalifying/resubmitting for regulatory approval.
- **Small:** Small package reduces the number of components needed to implement the sensor, enabling reduction in size and weight.
- **Stable:** Stability is a measure of how little the output signal of the pressure sensor will change from measurement to measurement.

TABLE 2. BOARD MOUNT PRESSURE SENSORS

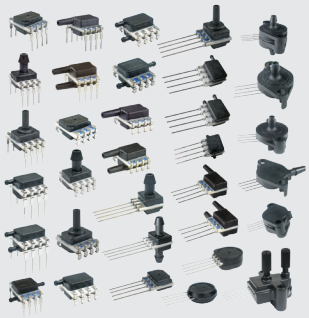
TRUSTABILITY™ RSC SERIES, HSC SERIES, SSC SERIES	FEATURES
	• Temperature compensation and calibration provide an amplified signal, typically allowing removal of components associated with signal conditioning from the PCB, increasing space and reducing associated costs • Enhanced stability often eliminates 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 increases application flexibility • RSC Series provides high 24-bit resolution and Total Error Band as low as 0.25 %FSS
26PC FLOW-THROUGH SERIES	**FEATURES**
	• 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

TABLE 3. HEAVY DUTY PRESSURE TRANSDUCERS	
13 MM SERIES AND 19 MM SERIES	**FEATURES**
	• 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
SPT SERIES	
	

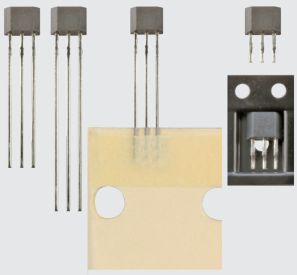
MAGNETIC SENSOR ICS

SS400 Series; SS360NT, SS360ST, SS460S

Hall-effect position sensor ICs (see Table 4) are designed to provide reliable, accurate output for smooth motor control that reduces noise and vibration in the machine's motor assembly and improves its efficiency. Their solid state reliability often reduces repair and maintenance costs, and its small size allows for design into many compact, automated, lower-cost assemblies. A thermally-balanced integrated circuit provides consistent operation over the full temperature range.

Benefits to Customer

- **Accurate:** For linear displacement and current sensing, analog Hall-effect sensors provide accurate and linear output, enabling an extended sensing range (SS400 Series).
- **Cost-effective:** Small sensor size allows for compact designs and automated, lower-cost assemblies and minimizes replacement costs.
- **Energy-efficient:** Hall-effect sensors consume little energy and help improve motor efficiency.
- **Quiet:** Reliable, accurate sensor output for smooth motor control enables low audible noise, and reduces motor vibration.

TABLE 4. HALL-EFFECT POSITION SENSOR ICS	
SS400 SERIES	**FEATURES**
	• Quad Hall-effect design minimizes effects of mechanical or thermal stress on output, and promotes a stable output • Unipolar, bipolar or 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
SS360NT, SS360ST, SS460S	**FEATURES**
	• Fastest response time in its class • No chopper stabilization • High sensitivity • Latching magnetics • Wide operating voltage range: 3 Vdc to 24 Vdc • Built-in reverse voltage • Durable design • RoHS-compliant material meets Directive 2002/95

NANOPOWER SERIES SM353LT, SM353LT	FEATURES
	• High sensitivity: 7 Gauss typ., 11 Gauss max. (SM351LT); 14 G typ., 20 Gauss max. (SM353LT) • Average current: 360 nA typ. (SM351LT) and 310 nA typ. (SM353LT) • Supply voltage range: 1.65 Vdc to 5.5 Vdc • Omnipolar sensing activates with either pole from a magnet • Temperature range: -40 °C to 85°C [-40°F to 185°F] • Push-pull output does not require external pull-up resistor • Non-chopper stabilized design • RoHS-compliant materials meet Directive 2002/95/EC • SOT-23 package
STANDARD POWER SERIES SM351RT, SM451R, SM353RT, SM453R	**FEATURES**
	• Magnetic sensitivities: - Ultra-high sensitivity (SM351RT and SM451R): For applications requiring ultra-high magnetic sensitivity (7 Gauss typ., 11 Gauss max.) - Very high sensitivity (SM353RT and SM453R): For applications requiring very high magnetic sensitivity (14 Gauss typ., 20 Gauss max.) • Package styles: - SOT-23 (SM351RT, SM353RT) supplied on tape and reel (3000 units per reel) - Flat TO-92-style (SM451R, SM453R) • Supply voltage range: 3 Vdc to 24 Vdc • Omnipolar sensing activates with either pole from a magnet • Temperature range: -40°C to 85°C [-40°F to 185°F] • RoHS-compliant materials meet Directive 2002/95/EC

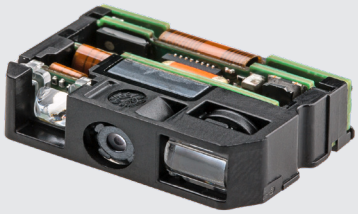
OEM 2D SCAN ENGINES

N660X Series

This product is designed to help provide barcode scanning ability, helping to verify treatment procedures as they are being delivered. (See Table 5.)

Benefits to Customer: Fast, accurate, small.

TABLE 5. OEM 2D SCAN ENGINES

N660X SERIES	FEATURES
	• Ultra-compact: The slimmest height in the industry at 6,8 mm [0.27 in] • MIPI interface available: Supports the latest technology trends for shorter design cycles • Optimized white illumination: Simplifies reading barcodes; highly visible aimer provides a clear, sharp and easily observed target area • Enhanced scan performance: Provides fast scan speed, ultra-fast motion tolerance up to 5 m/s, excellent reading capability for poorly printed barcodes, and support for color barcodes and full symbology • Adaptus 6.0 imaging technology: Quickly and accurately reads barcodes and OCR fonts with enhanced range and motion tolerance, even hard-to-read codes and those on mobile phone screens

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