Littelfuse
Expertise Applied | Answers Delivered

Application Note:
Position and Level Sensing in Washing Machine







Introduction

A most integral appliance in any home is a washing machine. Washing machines have helped make the chore of cleaning clothes quite effortless.

Like many modern appliances, washing machines today use a variety of sensors to ensure proper, safe, and energy-efficient operation. Littelfuse's magnetic sensor products help make these appliances as reliable as ever.

Reed sensors and Hall Effect sensors are both very reliable and will operate over millions of cycles with long-term integrity when used with microprocessor electrical loads. Both reed and Hall Effect devices are operated by a magnetic field. Reed switches and sensors consume no power, while Hall Effect devices are semiconductors and will consume a small amount of current in both the activated and de-activated state.

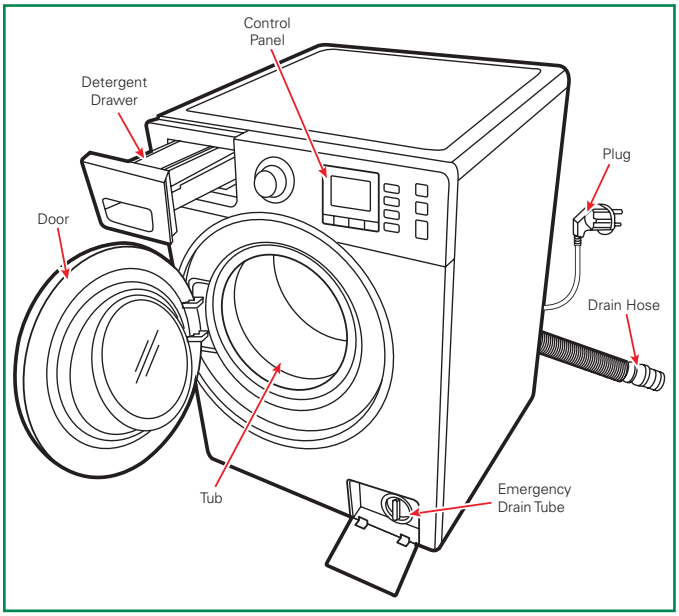


Figure 1: Components of a Washing Machine

Lid/Door Position Sensing

In top-load washing machines, the wash cycle begins by pumping water into the drum. As a safety precaution, the wash cycle doesn't begin the rotation of the drum unless the top lid is closed.

Typically, a micro switch can be used to detect when the lid is in the closed position. However, like many mechanical devices, micro switches tend to wear out over many close/open operations. Reed switches, on the other hand, are used as a longer-lasting alternative to micro switches. Reed switches offer the benefit of being contact-less sensors that can last for many close/open operations. A magnet is placed onto the moveable lid and actuates a reed switch that is mounted to the frame of washing machine near where the lid rests when closed. When the reed switch is closed, the microprocessor in the washing machine's electronics panel reads that the lid is closed and allows for the drum rotation to begin.

Similarly, in front-load washing machines, a reed switch can be used to detect whether or not the door is closed. A magnet is mounted to the swinging door and a reed switch is mounted to the frame of the washing machine near the door lock. When the door is closed, the microprocessor reads that the door is in the closed position and signals the lock mechanism to lock the door in place. The wash cycle can then begin or resume.

Not only can reed switches be used for lid and door position sensing, but reed sensors, provided in different housing types, can be used. Hall Effect sensors may also be used, especially in washing machines with microprocessor-controlled electronics.

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Table 1: Suggested Products as Lid/Door Position Sensor

Suggested Products
FLEX-14 reed switch
59040 reed sensor
59140 reed sensor
55100 Hall Effect sensor
Custom-designed door sensor

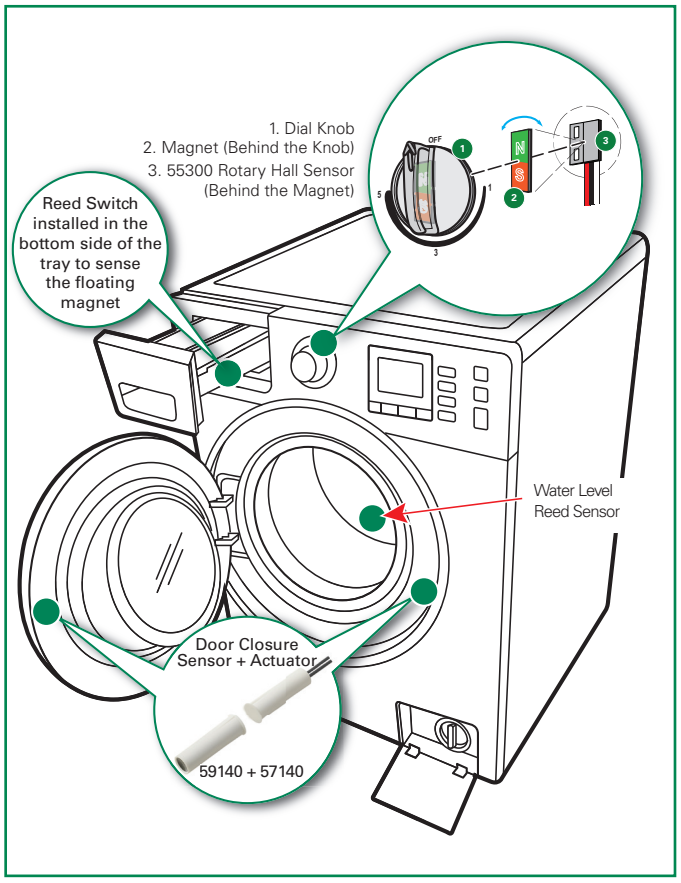


Figure 2: Sensor Positions in a Washing Machine

Water Level Sensing

A critical function of any washing machine is to know when water needs to be pumped into the drum and when water needs to be pumped out. The various wash cycles may depend on differing water levels in the drum, so it is important to be able to sense the water level within the drum.

An option to detect water level is a reed level float sensor. A typical float sensor consists of a reed switch housed within a shaft and a magnet imbedded into a float.

The float containing the magnet is free to move up and down along the shaft as the water level changes. The reed switch contacts located within the sensor tubular housing closes when the float magnet has moved within the reed switch's activation distance. This closure is sensed by the washing machine's microprocessor that the water level has reached its fill limit or its empty limit. The microprocessor can then signal the water pump to turn on or off accordingly.

Multiple levels can be sensed for lengths up to and beyond one meter by using reed switches designed into a resistive ladder output network. The reeds and resistors are placed on a circuit board with each reed switch typically spaced at 6mm or 12mm and are individually tied to a relative resistor. As the float moves up or down, a relative resistance or voltage output from each reed closure is sent to the microprocessor.

Reed level sensors also can be mounted with the float-magnet separate from the reed sensor assembly. The float can be within the water, while the reed sensor assembly can be mounted outside of the water drum isolated from the water.

Littelfuse can also design custom level sensor products tailored to specific applications. Sensor housings, assemblies, magnets, and sensitivities can be customized to meet the application needs.

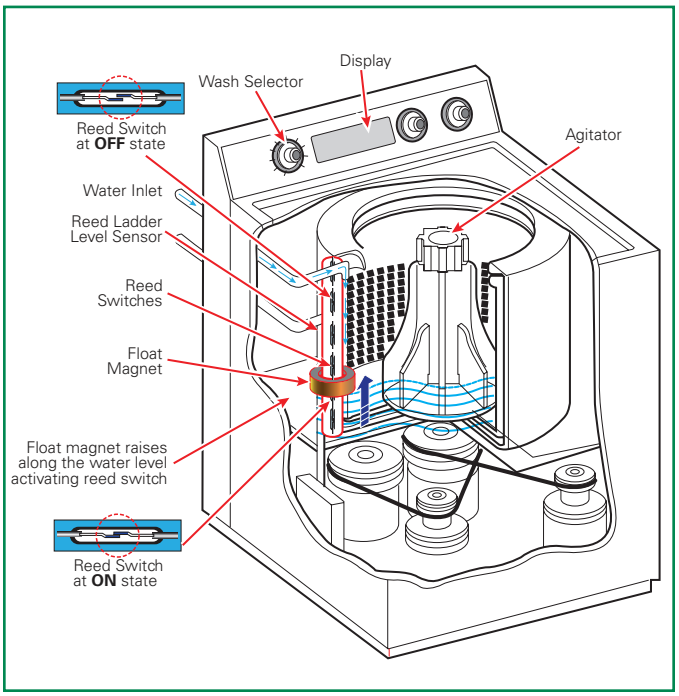


Figure 3: Flow Level Sensor in a Washing Machine

Table 2: Suggested Products as Flow Level Sensor

Suggested Products
59630 float sensor
Custom Float design
Custom reed ladder sensor design
Custom-designed level sensor

Dial Position Sensing

Whether it's selecting the wash cycle, soak level, or water temperature for your laundry, the rotating dial on a washing machine is an important user control. Traditionally, washing machines have employed mechanical selector switches for the rotating dial. However, being mechanical devices, selector switches tend to wear out over many close/open operations. Rotary Hall Effect sensors offer longer-term reliability since they can operate as rotary switches without the need to have any contacting mechanical parts.

A rotary Hall Effect sensor is a semiconductor device that responds to a magnetic field. The Hall Effect sensor can detect changes in the strength and direction of a magnetic field and output a signal to provide strength and angle information. In a washing machine, the Hall Effect sensor is mounted onto a printed circuit board in the electronics panel or onto the frame of the appliance, and a magnet is mounted on the rotating dial. When the dial is turned, the magnet rotates and changes the magnetic field detected by the Hall Effect sensor. The angle of the magnetic field can be detected by the Hall Effect sensor to determine the rotational position of the dial.

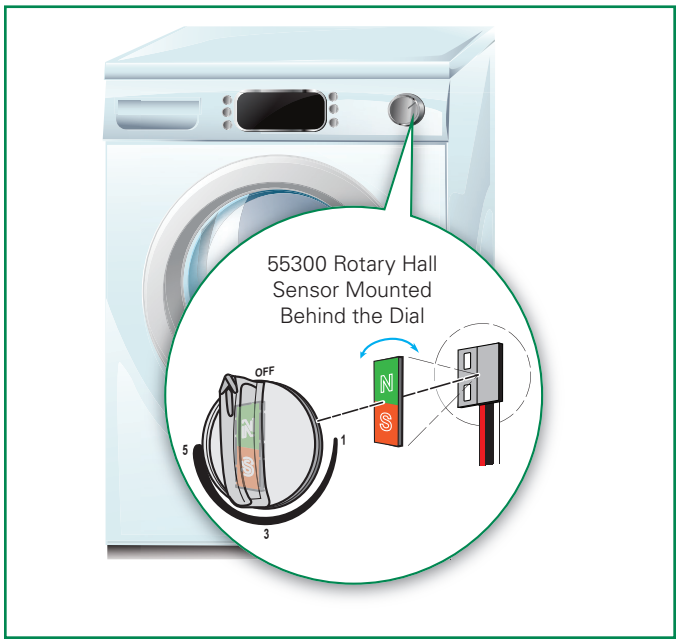


Figure 4: Dial Position Sensing in a Washing Machine

Table 3: Suggested Products for Dial Position Sensing

Suggested Products
55300 rotary Hall Effect flange mount sensor and mating magnet
Custom-designed rotary Hall Effect package

Drum Speed Sensing

Another key aspect of a washing machine system is control of the speed at which the drum rotates or spins. For many high spin rate top and front load machines, different wash cycles require the drum to spin at different speeds. A Hall Effect sensor is a very effective device used for detecting the rotating speed of a washing machine drum. Hall Effect sensors offer fine-resolution measurement and are well suited for high-speed applications.

A rotating multi-pole ring magnet is mounted onto the washing machine drum assembly and is used to monitor the speed of the drum's rotation. This magnet, usually containing 16 or 32 north and south poles, is attached to the drum axis, and rotates over top of the Hall effect speed sensor (as shown in Figure 5). This Hall detects the pole change frequency as the magnet rotates and is fed to the microprocessor. The microprocessor then determines if the speed is correct and signals the motor drive accordingly, if needed.

In addition to speed, Hall Effect sensors can detect the direction of rotation. A direction signal can be provided by either quadrature signaling or with the direction information encoded in the pulse width of the sensor's output signal. Quadrature signaling involves two square-wave speed signals with direction determined by the lead against lag phase relationship between the two signals.

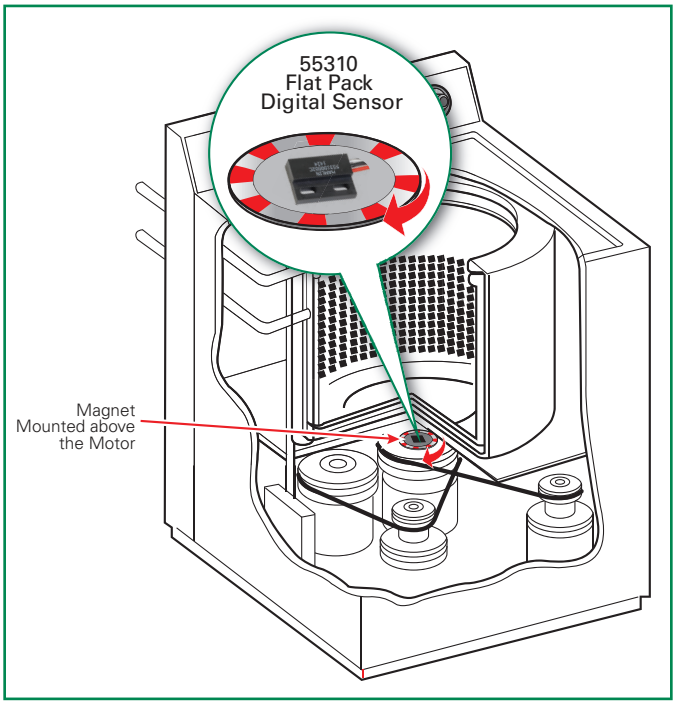


Figure 5: Standard Drum Speed Sensor in a Washing Machine

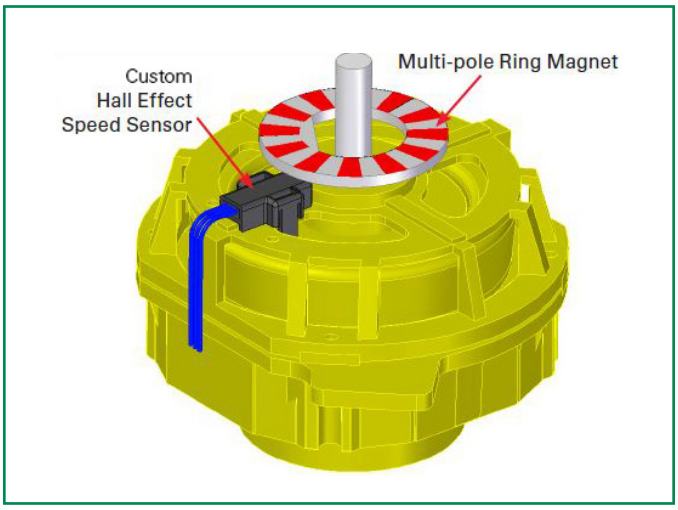


Figure 6: Custom Drum Speed Sensing in a Washing Machine

Littelfuse recommends the following products as drum speed sensor in a washing machine:

Table 4: Suggested Products as Drum Speed Sensor

Suggested Products
55310 flat pack digital sensor
Custom-designed Hall speed sensor

Detergent Level Sensor

Washing machines that use liquid detergents can be equipped with a level sensor that signals the operator when the detergent is too low and requires refill.

In this type of application, a custom designed floater that contains the magnet and lever mechanism that allows the floater to pivot up and down on top on the detergent surface. The magnet activates a reed switch of digital Hall effect when required for refilling.

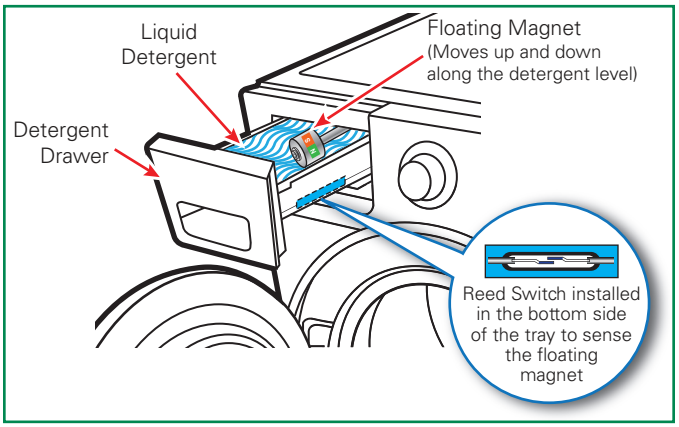


Figure 7: Detergent Level Sensor in a Washing Machine

Table 5: Suggested Products as Detergent Level Sensor

Suggested Products
55140 or 55100 flat pack digital Hall sensor
59140 reed sensor
Custom-designed floater with magnet

Why to Use Reed or Hall Sensor

A reed switch is a magnetically operated switch that in most situations are normally open when there is no magnetic field present. When a magnetic field is present in proper alignment and of sufficient strength, the contacts of the reed switch will close and complete the circuit.

Reed switches and Hall Effect sensors are magnetic switching devices, sometimes called 'contactless'; that is because the actuator/magnet does not make physical contact to the switch, to change the state, unlike a Micro-switch, or a Mechanical switch.

Reed switches are perfect technology for switching microprocessor electrical loads of 1-12Vdc and small milli-amps of current. Reed switches have precious metal contacts, hermetically sealed within a glass envelop and filled with nitrogen gas. The switching cycles can last up to many millions of operations with no degradation of contact wear, because of this inherent reed switch design.

A digital Hall Effect is a semiconductor with unlimited life when driven by the proper voltage and current. Reed and Hall Effect devices are long-lasting and very reliable within very humid and varying temperature applications.

FEATURES AND BENEFITS OF HALL EFFECT SENSORS

- No physical contact required to operate the sensor
- Wide operating temperature range
- Digital or analog options for output signal
- Programmable on both digital and analog applications for tight output tolerances
- Effective for high-speed applications
- Encapsulated sensors provide additional protection against mechanical stresses
- Long lifetime and reliable sensing for millions of operations

FEATURES AND BENEFITS OF REED SWITCHES

- Switch activation does not require physical contact
- Switch contacts are within a hermetically sealed capsule
- Resistant to moisture, dust, and other foreign objects
- Wide operating temperature range
- Reliable switching
- Long lifetime

Beyond Sensing, Littelfuse Offers Circuit Protection Solutions

In addition to sensor products, Littelfuse offers the world's broadest and deepest portfolio of circuit protection and power control solutions.

Littelfuse recommends the following products for use in these applications:

Table 6: Circuit Protection and Power Control Solutions

Application Example	Product Series
Power Control	
Heater AC Power Control	Q60xxxH6 Thyristors
AC Motor Control Heater Control Waste Pump	Q60xx Triac
Safety Latch Water Valve Light Control	QxNx Triac
Circuit Protection	
AC Mains	TMOV, LA, C-III MOV, UltraMOV Varistors
	3AG, 5x20mm Fuses
	Holders, Blocks, Clips
Control Board	TR5/TE5 Fuse
	SMD PTC
	P4KE/SMAJ TVS
Touch Screen/Display Panel	SP1001, SP1003, SP1006 Diode Arrays
	Multilayer Varistors

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