Gems™ Sensors & Controls

Liquid Level Sensing Technologies

Keeping tabs on fluids relies more than ever on sensors.
What sensing technology is best for you?

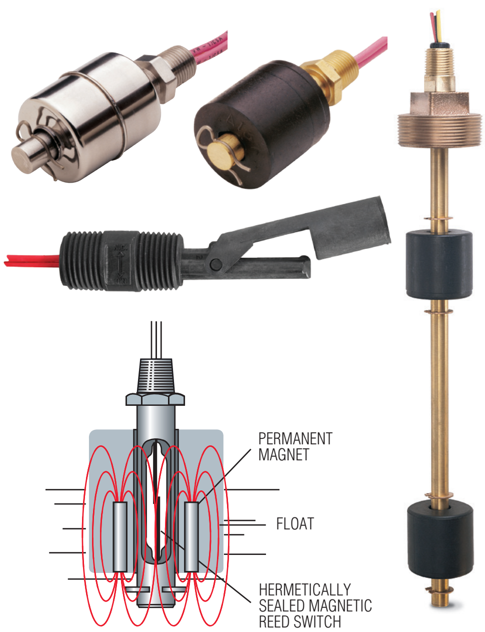





Fluids play a role in a wide variety of industrial, medical and consumer equipment built today. Virtually every piece of equipment or process system utilizing fluids incorporates a vessel that contains the fluid supply, whether it is a small reagent bottle for medical diagnostics, a large tank of acid in the process, or a hydraulic system on an agricultural tractor. Sensing fluid levels is critical to automating systems and protecting equipment. This article focuses on liquid level sensing and will assist in the decision process of selecting the best method for particular applications.

There are a wide variety of liquid level sensing technologies, all with strengths & weaknesses that suit them to different applications. This white paper will review the following commonly used level sensing technologies:

- Float or Buoyancy
- Conductivity
- Capacitance
- Ultrasonic
- Piezo Resonant
- Optical
- Load Cells



Float/Buoyancy

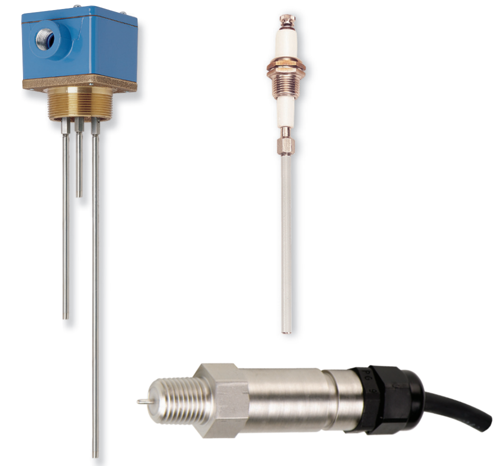
Pros: Non-powered, reliable, direct indication, relatively inexpensive, various outputs
Cons: Invasive, contact fluids, moving parts
Typical Applications: Water, oil, hydraulic fluids, chemicals, food and beverage, appliances. Best used in fluid with low particulate matter.

Manufactured in a variety of materials, shapes and sizes, there are float switches compatible with most fluids, and to fit within most tank shape and sizes. The most simple and inexpensive of the group utilize a reed switch that is actuated by a magnet embedded in a float that moves with the liquid level. This offers a very direct, reliable, and repeatable method of monitoring the liquid level within a tank. A magnetic field actuates the mechanical reed switch, so there are no power requirements to drive the sensor. Floats can be configured for single point switch actuation, or with many floats and switches on a single stem for multi-point level detection and switch actuation.

Some limitations are obvious: floats need to be inside the tank, in contact with the liquid. Volume displaced by a float sensor results in less fluid, or requirements for a larger container. Additionally, as instruments become smaller, less buoyant floats are limited by specific gravity in terms of the liquids that can be monitored.

Conductivity

Pros: No moving parts, low-cost, little fluid displacement, solid-state, easy to configure
Cons: Invasive, probe erosion, liquid needs to be conductive
Typical Applications: Boiler water, reagent monitoring

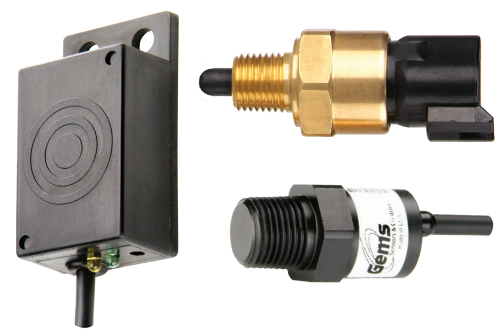


Conductivity sensors rely on the conductive nature of many liquids. In its simplest form, two metallic probes extend into a tank. The longer of the two probes carries a low voltage and acts as Ground. The second probe is cut so the tip is at the actuation point. When the liquid comes into contact with both probes, the current flows across the probes and a switch actuation occurs. These sensors are highly reliable in liquid dispensing and boiler application. Conductivity probes require an electronic controller.

Drawbacks include: saline and buffer solutions creating bridging issues and false actuation; when contamination from the probe is unacceptable; or when the conductivity of the liquid is low and/or varies.

Capacitance

Pros: No moving parts, can be non-invasive, accurate, small size
Cons: May require calibration, needs resistive liquids
Typical Applications: Reagent, waste, wash container levels, coolant monitoring

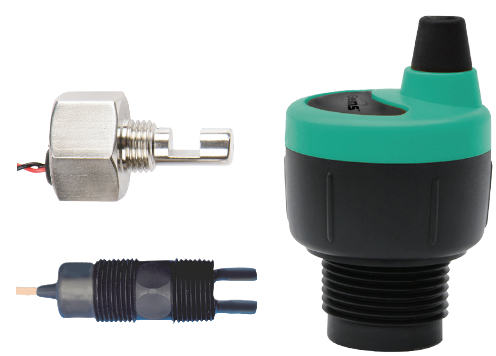


Capacitance sensors are available in contact and non-contact configurations. The operational premise is to measure the difference of dielectric properties between air and liquid media to determine level by identifying the presence or absence of liquid inside a container. At the point where the sensor is mounted the dielectric property of a substance is the quality of a material to resist holding an electrical charge. When a change in level causes a change in the total dielectric of the capacitance system, the capacitance measurement is used to indicate level. Capacitive sensors can be mounted against non-metallic vessel walls of appropriate thickness to achieve non-contact sensing.

Where all elements stay absolutely consistent, capacitance sensors can provide reliable results. Problems arise, however, when uniformity cannot be maintained. For example, changes in sensor/vessel position, vessel wall thickness, or fluid dielectric fluctuations can impair capacitance sensor performance and recalibration is necessary.

Ultrasonic

Pros: No moving parts, small, accurate, not affected by media properties
Cons: Expensive, invasive
Typical Applications: Large process tanks, waste tanks



Ultrasonic technology has long been used in a variety of sensor types: contact, non-contact, invasive, and non-invasive. This technology involves converting electricity into acoustic energy. Non-contact ultrasonic sensors bounce sound waves off the surface of a liquid and measure the return time infer liquid level within a tank. This type can be used for either point level switching or continuous level sensing.

Contact versions use sound transmissions to detect the presence of liquid or a change in state. A transmitting crystal sends sound waves to a receiving crystal. Ultrasonic sound waves are greatly attenuated when transmitted through air. Conversely, when the switch is immersed in liquid, the signal to the receiving crystal is greatly enhanced. Circuitry in the sensor analyzes the signal strength and actuates the switch appropriately. Regardless of the type, ultrasonic sensors are highly accurate, can be small, and are solid-state.

Even though they are highly accurate, ultrasonic sensors can be fairly expensive and require a power source for operation. While available in a variety of materials suitable for critical fluids, contact ultrasonic switches must be inserted into the tank or vessel, usually through a threaded fitting in the tank sidewall. In addition, the technology can deliver false positive readings from fluctuations in material composition such as air pockets or bubbles, foam, and solid particles in the liquid.

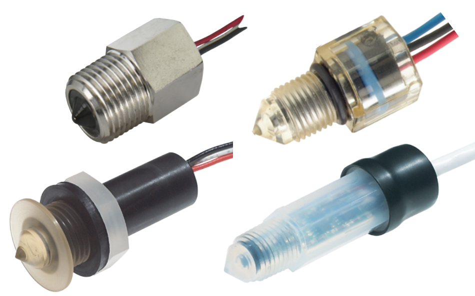
Piezo-Resonant

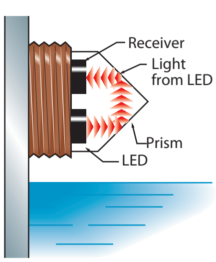
Pros: Non-invasive/non-contact, accurate, repeatable, and economical
Cons: Powered, works only with plastic containers, wall thickness, temperature limitations
Typical Applications: Plastic vessels where contamination is an issue, such as reagents, waste, diluents, wash, saline, pure water

Piezo-resonant sensors also use ultrasonic energy…but with a twist. This type of ultrasonic sensor allows non-contact fluid sensing through the walls of plastic bottles and containers. At this time, piezo-resonant technology is available only in the patented ExOsense™ sensors from Gems Sensors & Controls.

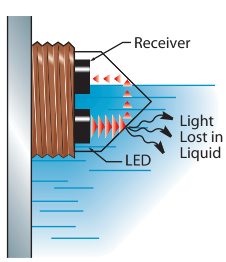
Piezo-resonant sensors adhere to the outside of plastic bottles/containers. They may be affixed anywhere on the outside of the tank to provide high, low or any intermediate point level fluid sensing. When piezoelectric material is excited, it creates an acoustic signal as a function of the natural resonance of the material. The sensor generates this acoustic signal, directs it through the bottle wall and senses the reflected pulse to determine whether air vs. liquid is present on opposite side of the container wall. Accuracy is ±1.6mm of actual liquid surface with repeatability within 1mm.

While this new technology is exciting and can lend itself to numerous applications, it is limited to certain types of tanks and bottles. The container must be plastic, and although the switch is unaffected by the color or transparency, the wall of the container can be no thicker than a 1/4 inch. The sensor cannot be used above 70°C (160°F).





Liquid below the sensing prism.



Liquid immersing the sensing prism.

Electro-Optical

Pros: Compact, no moving parts, high temperature capability
Cons: Invasive (minor protrusion through tank wall), powered, and can be affected by dried or coating media
Typical Applications: Coolants, medical diagnostics, sterilizers and washers, lubricants, food and beverage, hydraulics, leak detection

Electro-optic sensors integrate an optical prism tied to solid-state circuitry that combines an infrared light emitter and receiver with transistorized switching. They are low-cost and compact level sensors with built-in switching electronics. With no moving parts, these small units are ideal for a broad variety of point level sensing applications, especially where dependability and economy are a must. Electro-optic sensors are suitable for high, low or intermediate level detection in practically any tank, large or small. Installation is simple and quick through the tank top, bottom or side.

Performance can be hindered by reflected light, such as in a small reflective tank, bubbles, or coating fluids. Although they protrude very little into a container, they still require an entry through the container wall and must come into contact with fluids.

Load Cells

Pros: Continuous monitoring, non-invasive, no container modification
Cons: Changes in container, fluid density, container position
Typical Applications: Waste containers, very large tanks, extreme temperature

Load cells have the advantages of being non-invasive and requiring no wires running to the container being monitored. They measure container weight and infer the amount of fluid in the container as a function of a change in weight. The downside is the calibration needed to keep the system accurate. Variation in container weight or fluid density, or even the position of the container on the load cell platform may alter what the system "sees" as "full" or "empty".

Summary

As you can see, there are many choices for monitoring liquid level, and selecting the ideal sensor for any application can be challenging simply due to the number of good options. The challenge is determining the "best" option based on the application and design goals. One shortcut to finding a quick and successful solution is to work with a knowledgeable partner with broad product expertise and good application experience. By choosing a leading sensor company to work with, your design group can reduce risk, optimize resources, and speed development.

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