80 GHz radar vs. ultrasonic:

Non-contact Level Measurement Technology Comparison

When it comes to non-contact continuous level measurement, radar and ultrasonic are two of the most common technologies used. Both technologies are used for similar applications across industries, and both types of devices use similar principles to make a level measurement. However, each technology has varying degrees of success in different applications.

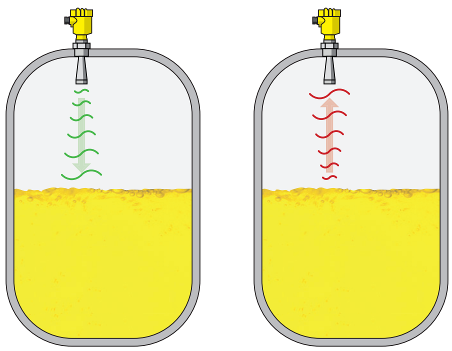
This paper will compare and contrast 80 GHz radar sensors with ultrasonic transmitters for liquid and solid level measurements. Users must consider many variables when choosing a level measurement technology, and this paper will discuss how each technology performs relative to several of these.

How the technologies work

Radar and ultrasonic instruments operate similarly. They both face downward, emitting a signal that reflects from the product surface, and the sensor electronics use the time of flight to calculate a measurement. The type and shape of signal each technology uses is where they begin to diverge. All radars, including 80 GHz radar sensors, emit radio microwaves, while ultrasonic transmitters use sound waves.

Radar

Radar microwaves are electromagnetic waves, which means the signal doesn't require a medium – it can travel in a vacuum. This is why radar signals are unaffected by process conditions like temperature and pressure. This makes radar technology a versatile level measurement technology across industries and applications.

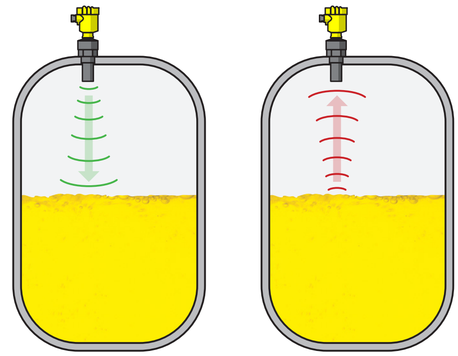


The newest radar sensors using a higher 80 GHz frequency have a very narrow beam angle – as small as 3.6°. Most of the energy from the radar signal is focused in a small area, and this allows the radar to avoid internal obstructions, mixers, or agitators inside the vessel. The exceptional focus of the radar beam also minimizes any additional "noise" or unwanted reflections that bounce around inside the vessel.

Ultrasonic

An ultrasonic sensor's sound wave is a mechanical wave, which means it needs a medium to travel through, and most of the time, that medium is the atmosphere or the air inside the vessel. The speed of the signal is contingent upon the environment in which it's traveling. Sound waves travel at different speeds depending on the air temperature, pressure, density, and gas composition. If any of these properties are changing during the process, it can result in measurement errors, which is why ultrasonic sensors are more ideal for simple level measurements in processes with little to no changing conditions.

Ultrasonic signals operate using frequencies ranging between 30 kHz and 240 kHz. Unlike radar, frequency is more of a function of measuring range, with low frequencies used for measuring longer distances and high frequencies used for measuring small distances. Some ultrasonic sensors can focus most of their signal as small as a 4 or 5° beam angle, but because of the shape of the acoustic waves, ultrasonic sensors are more likely to receive unwanted reflections from within the vessel.



Vessel size and construction

To begin choosing the right level measurement sensor, users must understand the shape, size, and material of their vessel. This will provide a better understanding of the measurement required by the sensor. It can also determine how and where the sensor will be mounted to obtain an accurate, reliable level measurement.

Radar sensors have traditionally been used for longer range level measurements in bigger tanks while ultrasonic sensors have excelled with shorter distances. As technology has developed, however, these conventions have begun to fade. Ultrasonic sensors are still more accurate with exceptionally small measurements less than six inches. For most small vessels, however, today's 80 GHz radar sensors perform just as well as their ultrasonic counterparts. Plus, these new sensors have small antennas with correspondingly small process fittings that make them suitable for these small tanks.

In large tanks with longer measurement spans, both radar and ultrasonic sensors perform well. However, users should be ready for a tradeoff when using ultrasonic sensors. The low frequency ultrasonic sensors used for long ranges typically require a larger opening at the top of the tank. Plus, all ultrasonic sensors have a near zone, or a "dead band," which is essentially a blind spot near the sensor where it can't make a measurement. Long-range ultrasonic sensors may have near zones exceeding three feet, while radar sensors enable users to measure all the way to the top of the tank.

The tank or vessel's construction can also play a factor in which technology to choose because this can factor into how a sensor is mounted. Radar signals can penetrate non-conductive materials like polyethylene, fiberglass, and glass. This allows radar sensors to measure through plastic vessels or sight glasses. An ultrasonic sensor would require a new process connection while the radar can simply be mounted above the vessel and make the same measurement non-intrusively.

Process Conditions

Every process has its challenges to obtaining an accurate level measurement. Steady, predictable conditions are a luxury in the process industry. Changing temperatures, foam, product reflectivity, dust, condensation, buildup, and noise are just a handful of potential hurdles to obtaining an accurate level measurement. It's up to the user to find the best technology for the task at hand.

Temperature

Radar level sensors are immune to any changing temperatures, while ultrasonic sensors' accuracy can vary drastically. To combat this, ultrasonic transducers come equipped with the ability to measure the temperature at the transducer. However, if the transducer temperature significantly varies from the air space near the product surface, the level measurement will be off.

Gas Composition

Similar to temperature, the composition of the gas between the sensor and the liquid surface has an effect on ultrasonic sensors' sound waves. The speed of sound varies greatly depending on the gas type, which can lead to measurement errors. Vapors from acids and solvents are especially susceptible to this, and it can greatly affect the accuracy of ultrasonic devices. Radar microwaves, on the other hand, travel at the same speed regardless of the air space, so the measurement will remain the same.

The measuring principle – Sound velocity in gases

Type	Sound velocity	Density (at 20°C)
Hydrogen	1280	0.0899
Helium	981	0.1785
Air	343	1.2041
Oxygen	317.5	1.429
Carbon dioxide	266	1.98
Sulphur hexafluoride	129	6.63

Foam

Foaming is another universal setback for any non-contact level measurement technology because foam absorbs both microwaves and sound waves. Complete absorption is rare, and in those extreme instances, a guided wave radar is the user's best bet. In most applications with light foaming, an 80 GHz radar can make a measurement through the foam as if it's not even there. Many ultrasonic manufacturers would require a standpipe for the same application.

Product reflectivity

The high sensitivity of VEGA's 80 GHz radar sensors allow them to measure even the most unreflective products. Liquids and materials previously unmeasurable with older radar sensors can now provide a strong enough signal to deliver an accurate, reliable level measurement. Unlike radar's electromagnetic waves, an ultrasonic's mechanical waves reflect off of most surfaces, despite its reflective properties.

Dust, condensation, and buildup

Users rarely find dust, condensation, and buildup in the same application, but all three have similar effects on ultrasonic sensors. Sound waves emitted from ultrasonic sensors require a medium to transmit energy from one place to another. Dust in the air presents a physical barrier for the energy transmission, which weakens the amplitude of the return signal. With condensation or buildup, the transducer diaphragm acts as the medium when it vibrates to produce a signal. Condensation or buildup here dampens the signal from the start. Yet, some ultrasonic sensors with low frequencies are better at handling these situations because the mechanical wave vibrates the sensor face, keeping it free of water droplets or buildup.

Radar sensors are unaffected by dust, condensation, and buildup. Sophisticated sensitivity software in VEGA's 80 GHz radar sensors ignores any signals returning to the sensor too quickly, removing the possibility of a false high-level resulting from condensation and most buildup. As for dust in the air, dust particles are 0.5 to 1.0 micrometers in size, much too small to affect the radar's microwaves with wavelengths measuring 3.5 to 4 mm. This means radar is able to continue measuring during filling and emptying cycles of the most dusty environments. This allows radar to accurately make a level measurement in any application with dust, condensation, or buildup.

Noise

Loud noises are common in bulk solids applications and inside silos as falling material creates a deafening environment. The loud noises create additional sound waves, and depending on an ultrasonic transmitter's frequency, this can interfere with the sound waves being used to make a measurement. This can lead to measurement errors during filling, emptying, and in noisy processes. Because radar level sensors use radio microwaves, the noise has no effect on the measurement.

Conclusion

In most level measurement applications, users would be wise to choose an 80 GHz radar over an ultrasonic transmitter. This doesn't mean ultrasonic sensors are obsolete by any means. Ultrasonic devices are a cost-effective, non-contact means of level measurement, but they're not as reliable or accurate in changing or difficult environments. Most industries don't have the luxury of stationary product in a stable environment, which is why an 80 GHz radar sensor is the right instrument for the job more often than not.

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