Difference Between Ultrasonic and Radar Type Level Transmitter

A practical guide to difference between ultrasonic and radar type level transmitter, covering the reader intent, the relationship to difference between ultrasonic and radar type level transmitter, key evaluation criteria, common risks, and the information the intended project audience should confirm before taking the next

level-measurement
Main topic: Radar Level Meters
https://www.level-meters.com/products/radar-level-meters/

In industrial process automation, selecting the correct non-contact level measurement technology is critical for operational efficiency, safety, and cost-control. While both ultrasonic and radar sensors provide non-contact measurement—meaning the instrument does not physically touch the medium—they rely on fundamentally different physical principles. Understanding the technical difference between ultrasonic and radar type level transmitter units is essential for engineers and procurement teams looking to optimize their liquid or solid level monitoring systems.

At Welk, we manufacture a comprehensive range of industrial level measurement instruments. While both technologies have their place in modern industry, the choice between them often depends on the specific environmental conditions, the physical properties of the medium, and the required precision of the application.

1. Understanding the Measurement Principles

Before comparing the two technologies, it is vital to understand how each generates a level reading. Both systems utilize the "Time of Flight" (ToF) principle, but they use different types of waves to achieve it.

Ultrasonic Level Measurement Principle

Ultrasonic level transmitters use a piezoelectric transducer to emit high-frequency sound pulses (typically between 20 kHz and 200 kHz). These sound waves travel through the air or gas space above the medium, reflect off the surface, and return to the transducer.

The sensor measures the time interval between the emission of the pulse and the reception of the echo. Since the speed of sound in air is known (approximately 340 m/s at 20°C), the distance to the surface can be calculated using the formula:

Distance = (Speed of Sound × Time of Flight) / 2.

Radar Level Measurement Principle

Radar Level Meters utilize high-frequency electromagnetic waves, typically in the microwave spectrum (ranging from 6 GHz to 80 GHz). Unlike sound waves, these electromagnetic pulses travel at the speed of light (approximately 300,000 km/s).

There are two primary types of radar technology used in level measurement:

1. Pulse Radar: Similar to ultrasonic, it sends a pulse and measures the time it takes to return.

2. FMCW (Frequency Modulated Continuous Wave): The transmitter emits a continuous signal with a constantly changing frequency. The difference in frequency between the emitted signal and the reflected signal is proportional to the distance. This method generally offers higher accuracy and better signal-to-noise ratios.

2. Key Technical Differences

The fundamental difference between ultrasonic and radar type level transmitter performance stems from how sound waves and electromagnetic waves interact with the environment.

Propagation Medium and Vacuum

Sound waves require a medium (gas or liquid) to travel. Therefore, ultrasonic sensors cannot function in a vacuum. If a tank is under a vacuum or a partial vacuum, there are no air molecules to carry the sound pulse.

In contrast, radar waves are electromagnetic and do not require a medium. They can travel through a vacuum, through various gas compositions, and are unaffected by changes in air density.

Sensitivity to Temperature and Pressure

The speed of sound is highly dependent on the temperature and density of the air it travels through. A change in temperature of just 1°C can result in a 0.17% error in distance measurement if not compensated. While most ultrasonic sensors include internal temperature compensation, they cannot account for temperature gradients (where the temperature at the sensor head is different from the temperature near the liquid surface).

Radar waves are virtually unaffected by temperature or pressure changes within the vessel. This makes radar the preferred choice for high-pressure boilers or high-temperature chemical reactors.

Impact of Dust, Steam, and Vapor

Ultrasonic waves are mechanical; they physically bounce off particles in the air. If a tank contains heavy dust (common in grain silos) or thick steam/vapor (common in hot water tanks), the ultrasonic pulse may reflect off the dust or be absorbed by the vapor before it ever reaches the liquid surface. This leads to "signal loss" or false readings.

Radar signals penetrate dust, steam, and most vapors with ease. Because the wavelength of a radar signal is different from the physical size of dust particles or vapor droplets, the signal passes through them and reflects only off the primary liquid or solid surface.

Surface Conditions: Foam and Turbulence

Foam is a challenge for both technologies, but they react differently. Foam can absorb ultrasonic sound waves, leading to no return echo. Radar waves may also be attenuated by foam, but high-frequency radar (such as 80 GHz) often has enough energy to penetrate light foam or reflect off the top of dense foam more reliably than ultrasonic pulses.

3. Practical Selection Table

To assist in the engineering selection process, the following table summarizes the performance of these two technologies across common industrial parameters.

Feature	Ultrasonic Level Transmitter	Radar Level Meter
Measurement Medium	Liquids and some solids	Liquids, solids, and slurries
Vacuum Compatibility	No	Yes
Max Temperature	Typically up to 80°C (176°F)	Up to 250°C+ (482°F+)
Max Pressure	Typically up to 3 Bar (43 PSI)	Up to 40 Bar+ (580 PSI+)
Accuracy	0.25% to 0.5% of range	1mm to 3mm (High precision)
Standard Range	0.3m to 15m	0.1m to 100m
Beam Angle	Wide (10° to 15°)	Narrow (3° to 8° with 80GHz)
Cost	Lower Initial Cost	Higher Initial Cost
Maintenance	Low (No moving parts)	Very Low (No moving parts)

4. Installation Considerations

When installing either type of transmitter, several mechanical factors must be considered to ensure a reliable signal.

The Blind Zone (Dead Band)

Both sensors have a "blind zone" directly beneath the sensor face where measurement is impossible. For ultrasonic sensors, this is the time required for the transducer to stop vibrating after emitting a pulse so it can begin "listening." For radar, it is a result of the near-field antenna characteristics.

Ultrasonic: Typically 0.2m to 0.5m.

Radar: Often smaller, sometimes as low as 0.05m in high-frequency models.

Beam Angle and Obstructions

The beam angle determines how much the signal spreads as it travels. If the beam hits a ladder, a cooling coil, or the tank wall, it will create a false echo.

Ultrasonic sensors generally have wider beam angles. This means they require a "clear path" that is wider than what a radar sensor needs. Modern Radar Level Meters using 80 GHz technology have extremely narrow beam angles (as small as 3 degrees), allowing them to be installed in tall, narrow nozzles or in tanks with many internal obstructions without interference.

Mounting Position

Avoid the center: Never mount a sensor in the exact center of a domed tank, as this can focus multiple reflections and confuse the sensor.

Avoid the fill stream: Ensure the sensor is not positioned directly above where the tank is being filled, as the falling liquid will disrupt the signal.

Perpendicularity: The sensor must be mounted perpendicular to the liquid surface to ensure the echo returns directly to the receiver.

5. Limitations and Constraints

While radar is often seen as the "superior" technology, it is not always the correct choice for every budget or application.

Dielectric Constant (Dk)

Radar relies on the dielectric constant of the material to reflect the signal. Materials with a low dielectric constant (like certain oils or liquefied gases) do not reflect radar waves well. If the Dk is below 1.4, a standard radar might struggle, and a guided wave radar (GWR) or a high-sensitivity ultrasonic unit might be required. Ultrasonic sensors do not care about the dielectric constant; they only care about the physical density of the surface.

Cost-Benefit Analysis

For simple, ambient-temperature water tank monitoring or open channel flow in wastewater plants, an ultrasonic transmitter is often the most cost-effective solution. It provides sufficient accuracy at a fraction of the price of a high-end radar unit. Radar should be reserved for applications where temperature, pressure, or vapor make ultrasonic unreliable.

6. Frequently Asked Questions (FAQ)

Q: Can I use an ultrasonic sensor for diesel fuel level?

A: It is possible, but not recommended. Diesel fuel vapors can change the speed of sound in the tank headspace, leading to inaccuracies. A radar level meter is much more reliable for hydrocarbon fuels.

Q: Does the color of the liquid affect the measurement?

A: No. Neither technology is affected by the color or transparency of the liquid, unlike optical or laser sensors.

Q: How does wind affect ultrasonic sensors in open-air applications?

A: Strong wind can "blow" the sound pulse away from the receiver or create noise, leading to erratic readings. Radar is unaffected by wind.

Q: Is radar safer for corrosive chemicals?

A: Both can be made with corrosive-resistant materials like PTFE or PVDF. However, because radar can measure through a sealed plastic window (tank top), the sensor can be completely isolated from the corrosive atmosphere, which is an advantage for radar.

Conclusion

The difference between ultrasonic and radar type level transmitter technologies essentially comes down to the environment of the application. Ultrasonic sensors are an excellent, budget-friendly choice for stable, atmospheric applications like water treatment and simple liquid storage. However, for complex industrial processes involving high temperatures, varying pressures, heavy dust, or steam, Radar Level Meters provide the precision and reliability required for modern industrial automation.

At Welk, we provide expert consultation to help you choose the right instrument for your specific process. Whether you require the cost-efficiency of ultrasonic or the robust performance of radar, our technical team is available to assist with configuration, selection, and after-sales support.