

Radar and Ultrasonic Level Transmitter Difference

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



level-measurement

Main topic: Radar Level Meters

<https://www.level-meters.com/products/radar-level-meters/>

In the field of industrial automation, selecting the correct non-contact level measurement technology is critical for operational safety, process efficiency, and cost management. Two of the most prevalent technologies used today are radar and ultrasonic transmitters. While both serve the purpose of measuring the distance to a liquid or solid surface without physical contact, their underlying physics, environmental tolerances, and application strengths differ significantly.

Understanding the radar and ultrasonic level transmitter difference is essential for instrumentation engineers and plant managers who must navigate challenging process conditions like steam, dust, high pressure, or vacuum. This guide provides a factual, technical comparison to assist in selecting the most reliable solution for your specific application.

| Understanding the Measurement Principles

Before comparing the two technologies, it is important to understand how each device interacts with the process environment.

| Ultrasonic Level Measurement Principle

Ultrasonic transmitters operate using mechanical sound waves. The sensor's transducer emits a high-frequency acoustic pulse (typically between 20 kHz and 200 kHz). These waves travel through the air or gas space in a tank, hit the surface of the medium, and reflect back to the transducer.

The device measures the "Time of Flight" (ToF)—the duration between the emission of the pulse and the reception of the echo. Since the speed of sound in air is approximately 340 meters per second (1,115 feet per second) at 20°C (68°F), the distance can be calculated. However, because sound is a mechanical wave requiring a medium (air/gas) to propagate, its speed is highly sensitive to changes in air temperature, pressure, and gas composition.

| Radar Level Measurement Principle

Radar Level Meters utilize electromagnetic waves, specifically microwaves, rather than sound. These waves travel at the speed of light (approximately 300,000 kilometers per second). There are two primary types of radar technology used in level measurement:

1. **Pulse Radar:** Similar to ultrasonic, it sends a microwave pulse and measures the Time of Flight.
2. **FMCW (Frequency Modulated Continuous Wave):** The transmitter emits a continuous signal with a varying frequency. The difference in frequency between the emitted and received signal is proportional to the distance.

Unlike sound, electromagnetic waves do not require a medium to travel and can propagate through a vacuum. They are also largely unaffected by changes in temperature or pressure within the tank.

| Primary Factors Defining the Radar and Ultrasonic Level Transmitter Difference

The choice between these two technologies usually comes down to the environment in which the sensor must operate. The following factors highlight the core technical differences.

| 1. Medium of Propagation and Vacuum Stability

Ultrasonic waves are mechanical vibrations. They cannot travel through a vacuum. If a process involves a vacuum or low-pressure environment, ultrasonic sensors will fail to return a signal. Radar, being electromagnetic, is perfectly suited for vacuum applications and high-pressure vessels where the density of the gas phase might fluctuate.

| 2. Sensitivity to Temperature and Pressure

The speed of sound varies by approximately 0.17% for every 1°C change in temperature. While most ultrasonic transmitters include integrated temperature compensation, this only measures the temperature at the sensor head, not the entire vapor space. Significant temperature gradients can lead to measurement errors. In contrast, radar signals are unaffected by temperature and pressure variations, making them the standard for high-temperature reactors or high-pressure liquefied gas tanks.

| 3. Influence of Steam, Dust, and Foam

Steam and Vapor: Ultrasonic waves are easily scattered or absorbed by heavy steam or thick vapor clouds, often leading to a loss of signal. Radar waves penetrate most vapors and steam without significant attenuation.

Dust: In solid level measurement (e.g., grain or cement silos), dust can block ultrasonic signals. High-frequency radar (such as 80GHz units) can penetrate dust clouds to provide accurate readings.

Foam: Both technologies struggle with foam, but in different ways. Ultrasonic signals are often absorbed by foam. Radar signals may be reflected by the top of the foam or pass through it to the liquid, depending on the foam's density and dielectric constant.

| 4. Material Properties: Dielectric Constant vs. Acoustic Reflectivity

Ultrasonic sensors depend on the physical density of the surface to reflect sound. Radar sensors depend on the Dielectric Constant (ϵ_r) of the material. Materials with a high dielectric constant (like water, $\epsilon_r \approx 80$) reflect radar signals very strongly. Hydrocarbons and oils have lower dielectric constants ($\epsilon_r \approx 2$), which require more sensitive radar antennas or specialized FMCW processing to ensure a reliable echo.

Comparative Selection Table

Feature	Ultrasonic Transmitters	Radar Level Meters
Measurement Medium	Sound Waves (Mechanical)	Microwaves (Electromagnetic)
Vacuum Compatibility	No	Yes
Max Temperature	Typically up to 80°C (176°F)	Up to 450°C (842°F) or higher
Max Pressure	Typically up to 0.3 MPa (43 PSI)	Up to 16 MPa (2320 PSI) or higher
Standard Range	0.25m to 15m (0.8ft to 49ft)	0.1m to 100m (0.3ft to 328ft)
Accuracy	0.25% to 0.5% of range	1mm to 3mm (High Precision)
Cost	Lower Initial Investment	Higher Initial Investment
Maintenance	Low (No moving parts)	Very Low (Non-contact)

Application-Specific Recommendations

When to Choose Ultrasonic

Ultrasonic sensors are cost-effective solutions for straightforward applications. They are widely used in the water and wastewater industry for:

Open Channel Flow: Measuring flow over weirs and flumes.

Sump and Wet Well Level: Monitoring water levels in pits where conditions are relatively stable.

Chemical Storage: Small plastic tanks containing acids or bases at ambient temperatures.

| When to Choose Radar

Radar is the preferred choice for complex industrial processes where reliability is non-negotiable. Welk recommends Radar Level Meters for:

Oil and Gas: Storage tanks and separators where vapors and high pressures are present.

Chemical Processing: Reactors with high temperatures, agitation, and volatile chemical vapors.

Solids and Powders: Large silos for cement, coal, or minerals where dust is a constant factor.

High-Precision Inventory: Custody transfer applications requiring millimeter-level accuracy.

| Installation and Maintenance Considerations

Regardless of the technology chosen, proper installation is the most significant factor in long-term performance.

| Beam Angle and Obstructions

Both radar and ultrasonic sensors emit a conical beam. Any internal tank structures—such as ladders, heating coils, or agitators—that enter this beam will create "false echoes."

Radar Advantage: Modern high-frequency radar (80GHz) has a very narrow beam angle (as small as 3°), allowing it to be installed in narrow nozzles or tanks with many internal obstructions.

Ultrasonic Limitation: Ultrasonic beams are generally wider (typically 10° to 12°), requiring a larger clear path to the liquid surface.

| The "Dead Zone" (Blocking Distance)

All non-contact sensors have a "dead zone" or blocking distance directly beneath the sensor where measurements cannot be taken. For ultrasonic sensors, this is usually 0.25m to 0.5m (0.8ft to 1.6ft). For radar, the dead zone is significantly smaller, often just a few centimeters, allowing for better utilization of the full tank capacity.

| Mounting Position

Sensors should never be mounted in the center of a tank (to avoid multiple reflections from the tank walls) or too close to the wall (to avoid signal interference). Ideally, they should be positioned at 1/2 to 1/3 of the tank radius from the wall. Additionally, the sensor must be mounted perpendicular to the liquid surface to ensure the signal reflects directly back to the receiver.

| Frequently Asked Questions (FAQs)

Q: Can radar measure the level of a liquid through a plastic tank wall?

A: Yes. Because microwaves can penetrate non-conductive materials like plastic or glass, radar transmitters can often measure the level from outside a plastic IBC or storage tank without a hole being cut in the vessel.

Q: Why is ultrasonic still used if radar is more robust?

A: Cost is the primary driver. For simple water storage or atmospheric tanks where no steam or dust is present, ultrasonic transmitters provide a highly reliable and accurate solution at a fraction of the cost of a high-end radar unit.

Q: Does agitation affect the measurement?

A: Heavy agitation creates turbulence and waves. This can scatter the signal for both technologies. However, radar units often have more advanced software algorithms (False Echo Suppression) to filter out the noise from agitator blades and turbulent surfaces.

Q: How does the dielectric constant affect radar selection?

A: If the material has a dielectric constant below 2.0, a standard non-contact radar may struggle to see the surface. In these cases, a Guided Wave Radar (GWR), which uses a probe to guide the signal, is often recommended.

| Conclusion

The radar and ultrasonic level transmitter difference centers on the physics of the signal. Ultrasonic is an excellent, cost-effective choice for stable, ambient-temperature liquid applications like water treatment. However, for industrial processes involving temperature extremes, pressure variations, steam, or dust, radar technology provides the superior reliability and precision required for modern automation.

When selecting a level instrument, always evaluate the chemical compatibility of the wetted parts, the dielectric constant of the media, and the physical constraints of the tank. For high-performance industrial environments, Radar Level Meters offer the versatility and robustness needed to ensure continuous, maintenance-free operation.