Radar: A Simple, Economical Alternative For Level Measurement

by: Boyce Carsella Jr.

Radar has been part of the level measurement market for more than 30 years. While early designs used in tank gauging/custody transfer were heavy, expensive, power-hungry and complex, there have been numerous advancements in radar circuitry resulting in a modern radar transmitter that is light, inexpensive, loop-powered and easy to use. These new designs are a logical extension of the evolution that began years ago and pushes this premium technology into competition with other, more common level measurement technologies, such as ultrasonic.

It is common knowledge that the two technologies are very similar, yet very different. Ultrasonic is a versatile, widely-used technology that has been popular for many years. Radar is becoming popular but has been used less due to cost, although, technically, it is a superior technology that can be used in a wider range of process conditions. In one of their marketing research papers, ARC (Automation Research Council) commented "the greatest threat to ultrasonic technology is non-contact radar".

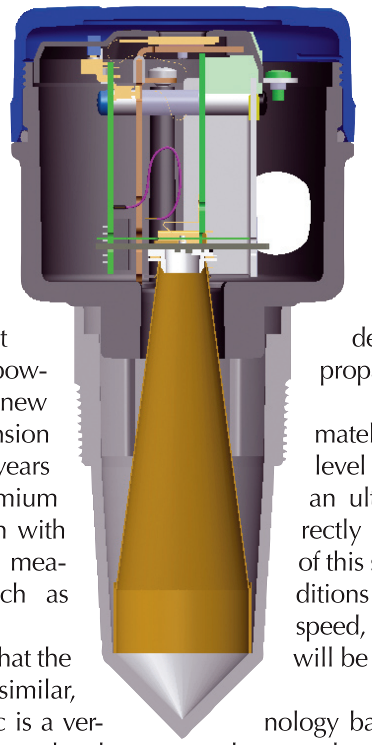
For years the industry has known that some future, economical radar transmitter would become a major competitor to ultrasonic; that reality is now upon us. The choice between an ultrasonic and a radar level transmitter is no longer price dependent. It is now simply a technical discussion of capabilities.

A look into the technologies

Both Ultrasonic and Radar are non-contact technologies; transit time devices that measure the time necessary for their energy to reach the liquid surface and be reflected back. The two technologies are even starting to look like twins – but this is where the similarities end and the significant, technical differences begin.

Ultrasonic

Did you ever wonder why sounds seem to travel better on some summer evenings or why it is always difficult to communicate with someone when shouting into the wind? Sound is a mechanical form of energy that propagates by vibrating the molecules within a vapor space. For human communication this is vibration of the air around us. In industrial level measurement applications it is the vapor space above the liquid. This has a significant and sometimes deleterious effect on the propagation of sound.



This transmitter features an inexpensive horn antenna fully encapsulated in either polyproylene or Tefzel. The bottom of the horn is a radome designed to focus the microwave energy while allowing condensation to form and drip off the tip.

Sound travels at approximately 1000 ft./second at sea level (14.7psi). The accuracy of an ultrasonic transmitter is directly based on the consistency of this speed. If vapor space conditions change the propagation speed, the transmitter accuracy will be affected.

Level measurement technology based on sound waves has become known generically as "ultrasound" meaning its frequency is above that of the human ear (typically 20-20kHz).

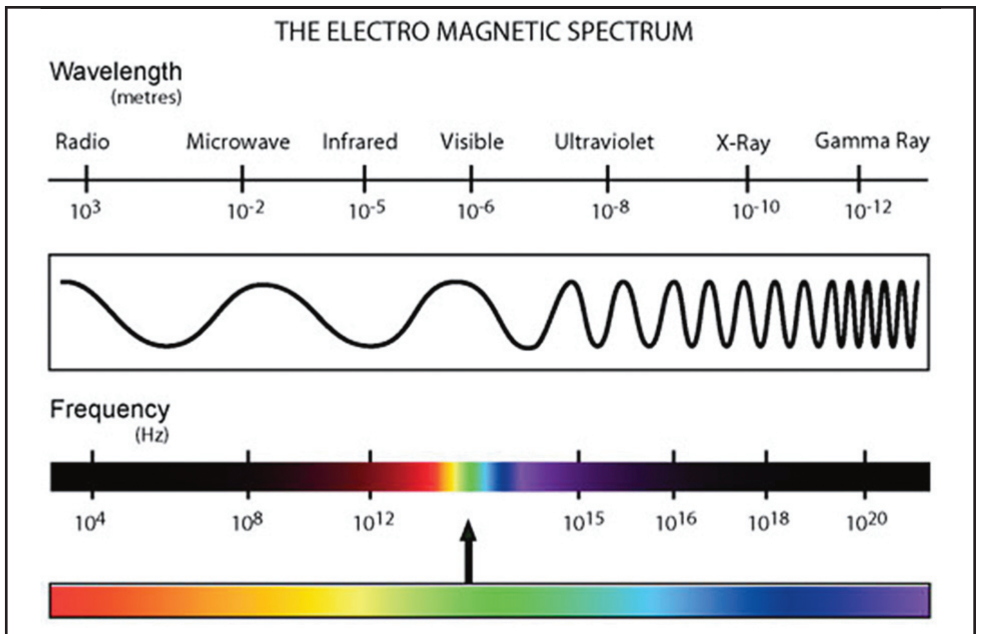
In actual implementation the transducer can be in a frequency range anywhere from approximately 5kHz on the low end (within the range of human hearing, i.e., "sonic") to near 100kHz on the high end. Low frequency transducers are used for long range applications and those where the sound must penetrate dirty, dusty environments. The downside is the transducers are very large and expensive. Transducers in the 80-100kHz range are much smaller and offer better resolution. However, high frequency sound is highly attenuated (weakened) as it propagates through the vapor space.

The most common transducer is a compromise between the two frequency extremes in the 40-50kHz range. This range yields a compromise of size, cost, maximum range (attenuation) and vapor space performance (penetration).

Radar

How can we feel the sun's energy from 93 million miles away or detect bursts of gamma rays from a distance of millions of light years but cannot hear sounds from nearby planets? Electromagnetism is a form of energy that propagates over long distances even through a vacuum or the ether of space. Electromagnetic energy travels at the speed of light (~1000 ft./uS) which is approximately 1 million times faster than the speed of sound.

Radar is an acronym that is derived from its original name RAdio Detection And Ranging. It uses the term "radio" since the original radar frequencies were in the radio band of the electromagnetic spectrum.



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Today's radar used for process level measurement is a higher-frequency, microwave-based technology typically in the range of 6-26GHz. This allows for a compact, and now cost-competitive device that yields significantly superior performance to ultrasonic.

Technology Comparison

As is now understood, today's loop-powered, microwave-based radar is a superior measurement technology to ultrasound with its ability to operate effectively in a wider range of process conditions. In typical application conditions, there's a clear advantage to radar, as shown in Table 1.

Again, the key reason that Radar is superior over Ultrasonic lies in the technologies itself. Ultrasonic is a mechanical form of energy that propagates by vibrating the actual air/vapor space through which it moves; air/vapor space conditions have significant effect on the propagation of sound. Radar is an electromagnetic form of energy that does not use the air/vapor space to propagate; rather, it travels through it.

The kind of daily application complications we all experience are more easily addressed using a radar technology. With the cost barrier now broken, radar is becoming an easier choice.

Further differences

- **Nozzles/Minimum Blocking Distance** – How much useable space is available at the top of the tank is often an issue. The problem for both technologies is "ringing" caused by launching energy into a nozzle. Ultrasonic and many Radar devices avoid this by forcing the transducer to be mounted below the nozzle and into the vessel. The new 26GHz radar devices can be recessed slightly into the nozzle thereby minimizing the "dead space" at the top of the tank.
- **Beam spread** – Both technologies have something called beam spread. The farther you get from the antenna, the larger the area the beam covers. Ideally you want to minimize obstructions in this area. However, how the beam spreads is different between the two technologies – ultrasonic beam spread is circular while radar beam spread is oval.

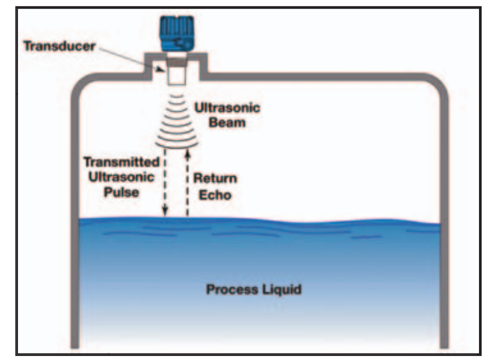
Radar can exploit this situation by allowing the beam to be adjusted for tank conditions. Even a low cost radar transmitter has an effective internal polarization adjustment that allows you to orient the beam for improved performance with obstructions.

As you can see, the radar beam is easily adjusted for optimum performance prior to any signal processing to map out any remaining obstructions.

The Modern Radar Transmitter

The Radar level measurement device today is a far cry from the original devices that came to market in the 1970s. The original radar level measurement devices were modified aircraft altimeters installed on large storage vessels and given the name "level transmitter". They had to be mounted with a crane and setup was so complex a technician was needed in every box.

Today the modern transmitter weighs only a few pounds, is simple and fully optimized for the task at hand, effective level measurement.



Both Ultrasonic and Radar are non-contact technologies that measure the time necessary for their energy to reach the liquid surface and be reflected back.

Summary

Ultrasonic level measurement is a wonderful technology that has proven itself over many years. It is simple, understood by thousands and will continue to be a major player in the level measurement market. Modern, loop-powered Radar is a relative newcomer but is gaining supporters rapidly. Until today, it has had the disadvantage to ultrasonic in that it was a far too expensive replacement in simple, daily applications.

The new, economical radar transmitter is now the answer to almost every, daily level measurement application imaginable. With new radar transmitters entering the market at <$1,000, cost is no longer a prime consideration. The significant performance advantages and economical price offered by today's microwave-based radar make it a candidate for even your most generic applications.

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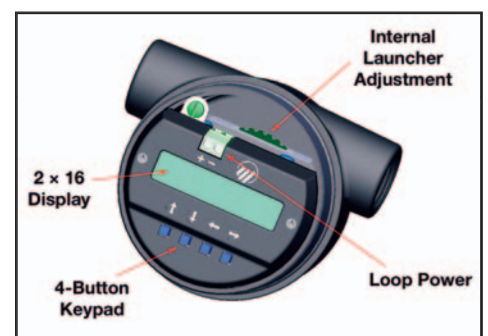
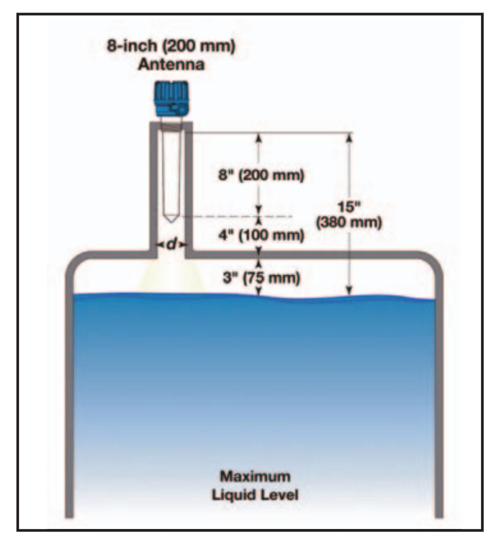
Magnetrol



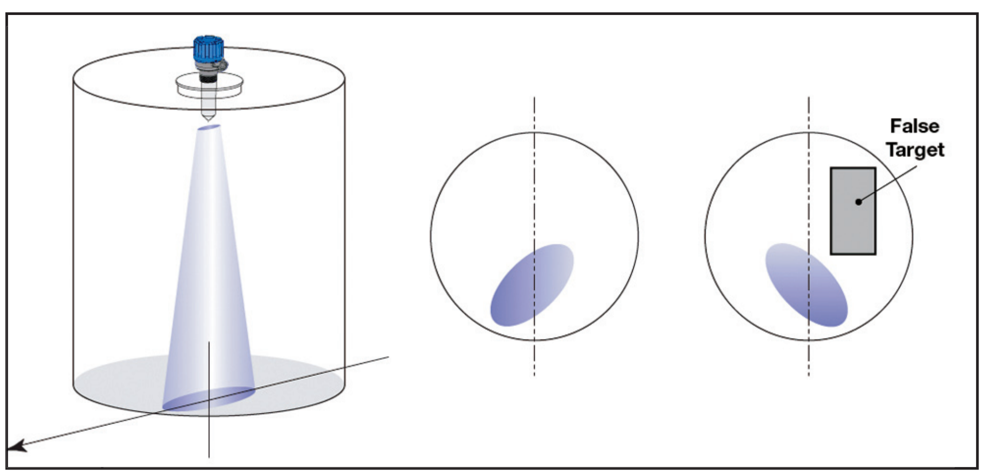
The radar beam can be easily adjusted for optimum performance.



The new 26GHz radar devices can be recessed slightly into the nozzle, minimizing "dead space: at the top of the tank.

Application Issues	Ultrasonic (loop)	Radar (loop)
Range	<40 feet	>60 feet
Minimum Blocking Distance	10-15 inches	<3 inches
Vapors	Unstable performance	No effect
Gas Blanketing	Unstable performance	No effect
Pressure >Atmos	Unstable erformance	No effect
Pressure >50 psig	Transducer will not flex; ultrasonic will not work	No effect
Vacuum	Will not propagate	No effect
Temperature Gradients	Unstable performance	No effect
Heavy Turbulence	Degraded performance	Minor degradation
Foam	Degraded performance	Degraded performance
Wind	Unstable performance	No effect

Table 1: In typical applications, there's a clear advantage to radar.



Ultrasonic beam spread is circular, while radar beam spread is oval. The radar beam spread can be turned to ignore a false target in the vessel.