OMC Technical Brief - Ultrasonic Distance Sensor

Ultrasonic distance sensors measure the time for a pulse of sound to travel to a surface and return, then calculate distance from the estimated speed of sound

What does it do?

Measure distance with an accuracy of a few centimetres, over a range of a few metres, at a speed of milliseconds to several seconds per sample.

Why use this technique?

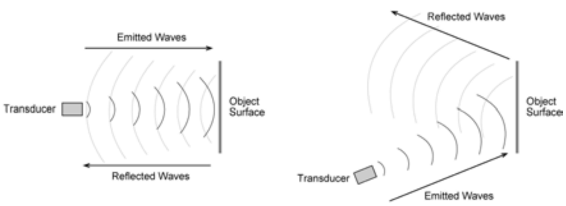
Ultrasonic sensors can offer a number of advantages over optical methods. Most notably, they can be used for measuring distance to any surface, including glass and liquids. Ranges vary from a few millimetres to around ten metres, without increasing the size of the device.

Typical objects measured:

- liquid level measurement
- counting objects on a production line
- thread or wire break detection
- robotic sensing for navigation or obstacle avoidance
- wall-to-wall distance measurement

How do ultrasonic rangefinders work?

Typically, an ultrasonic rangefinder sends a 'ping' and waits to hear an echo. Sound waves propagate from the transmitter and bounce off objects, returning an echo to the receiver (below left). If the speed of sound is known, the distance to an object can be calculated from the time delay between the emitted and reflected sounds.



Operation of an ultrasonic transducer

While the principle of calculating distance from the time of travel is simple, there are many limiting factors to consider. Sound diverges very rapidly, so transducers are carefully designed to produce as small a beam as possible. While some applications require a wide beam, a narrow beam improves the range and reduces background interference. There is a direct relationship between beam width and target surface angle: the wider the beam, the greater the possible angle between the transducer and the surface. When the angle is too great (>12 degrees), the reflected beam misses the transducer (above right). While some surfaces may produce scattered diffuse reflections, these are much weaker and are not used for distance measuring purposes.

The speed of sound varies with temperature: as air gets warmer, sound travels faster. Hence ultrasonic systems must incorporate a thermometer to estimate the current speed of sound. While the ambient air temperature can be measured, other warming effects, such as convection and turbulence, can cause errors in the calculated distance.

Humidity alters the attenuation of sound in air, which determines the maximum range of an ultrasonic device. Attenuation is also related to the frequency of the emitted sound: higher frequencies improve the sampling resolution, but attenuate more thus reducing the range.

What are the benefits of this system?

- long distance, up to 10 metres
- works with almost any surface type
- resistant to vibration, radiation, background light and noise
- unaffected by dust, dirt or high humidity
- low cost

What are the limitations of this measuring technique?

- moderate accuracy: 0.1 to 2% of the range
- large beam hence poor object resolution
- limited speed
- restricted target angle: requires near-perpendicular surface

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