SENSOR PARTNERS

Start Knowledge base *How does an ultrasonic sensor work?*

How does an ultrasonic sensor work?

Ultrasonic sensors work by sending and receiving sound. How does this work? How does an ultrasonic sensor work? What is ultrasonic sound? This article discusses these subjects.

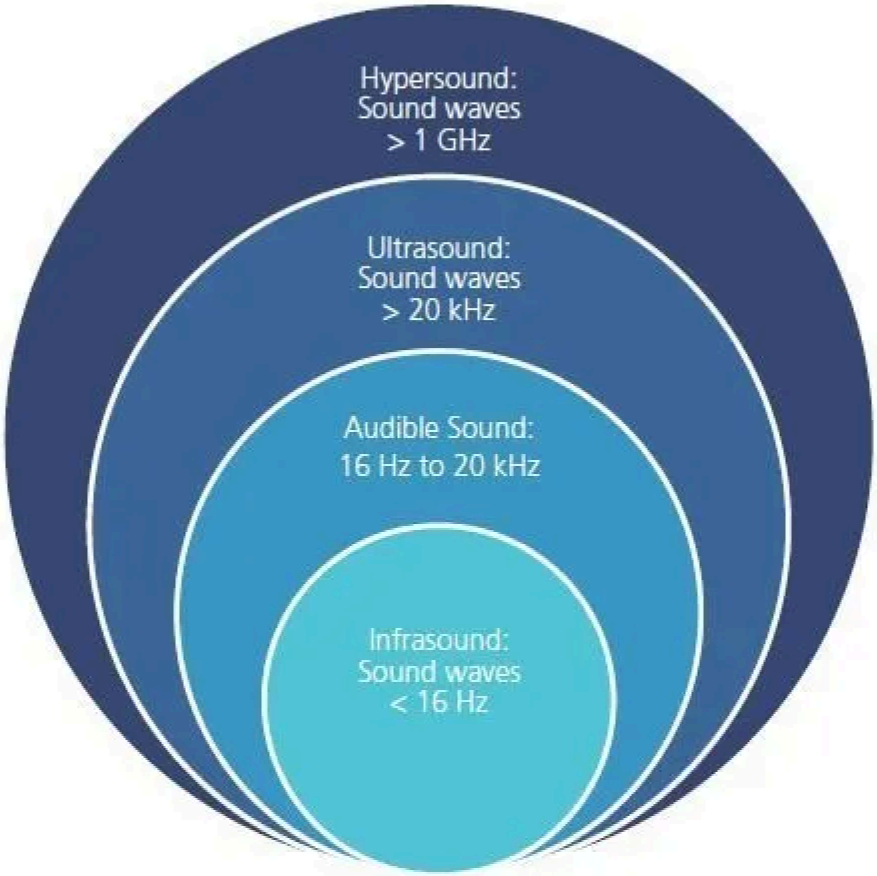
Want to know more?

What is (ultrasonic) sound?

A ultrasonic sensor uses sound to make a measurement. To understand how an ultrasonic sensor can perform this distance measurement, it is important to first know what sound is.

...uces sound, air molecules are ...n the spot and these air ... that moves through the air ...ating motion is called ... waves per second.

...m 20 Hz and 20,000 Hz (20 ...Hertz) is called ultrasonic



What is the speed of sound?

The speed that sound is being reproduced is depending on the medium. The speed of sound through air which is the medium that our ultrasonic sensors use for the measurement is slower than the speed of sound through liquids or solids. In the chart below are a few examples where the value is displayed in meters per second. Sound through air has a speed of 344 meters per second at a temperature of 20°C.

ork?

We now know what sound is and how and with what speed it moves through the air. How is this out to use by an ultrasonic sensor?

An ultrasonic sensor emits a sound pulse in the ultrasonic range. This sound pulse propagates at the speed of sound through air (about 344 meters per second) until the
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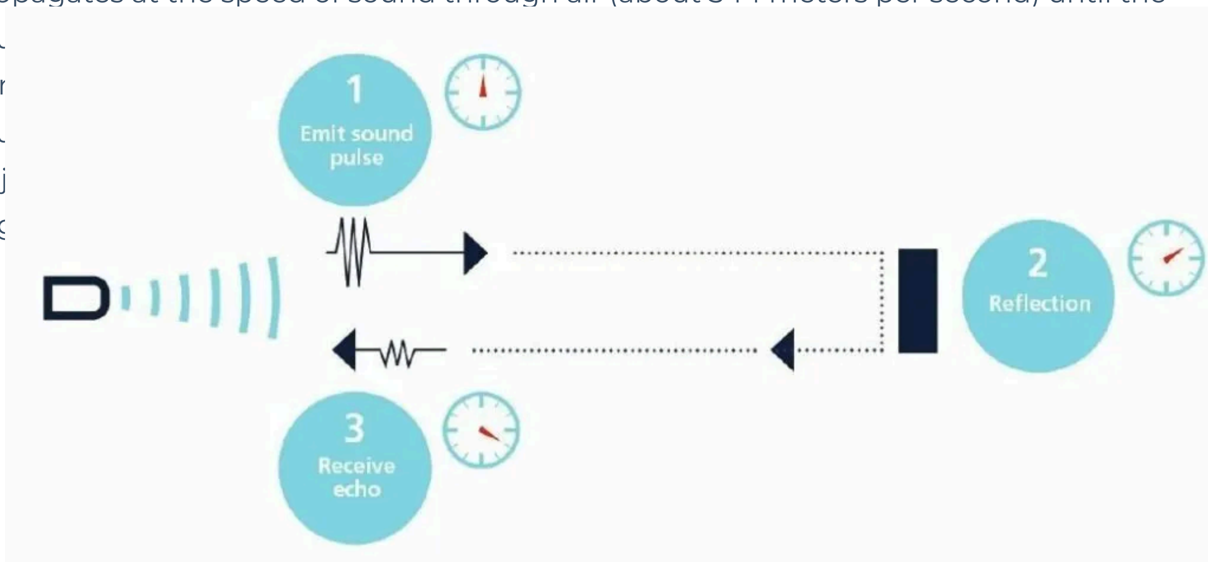
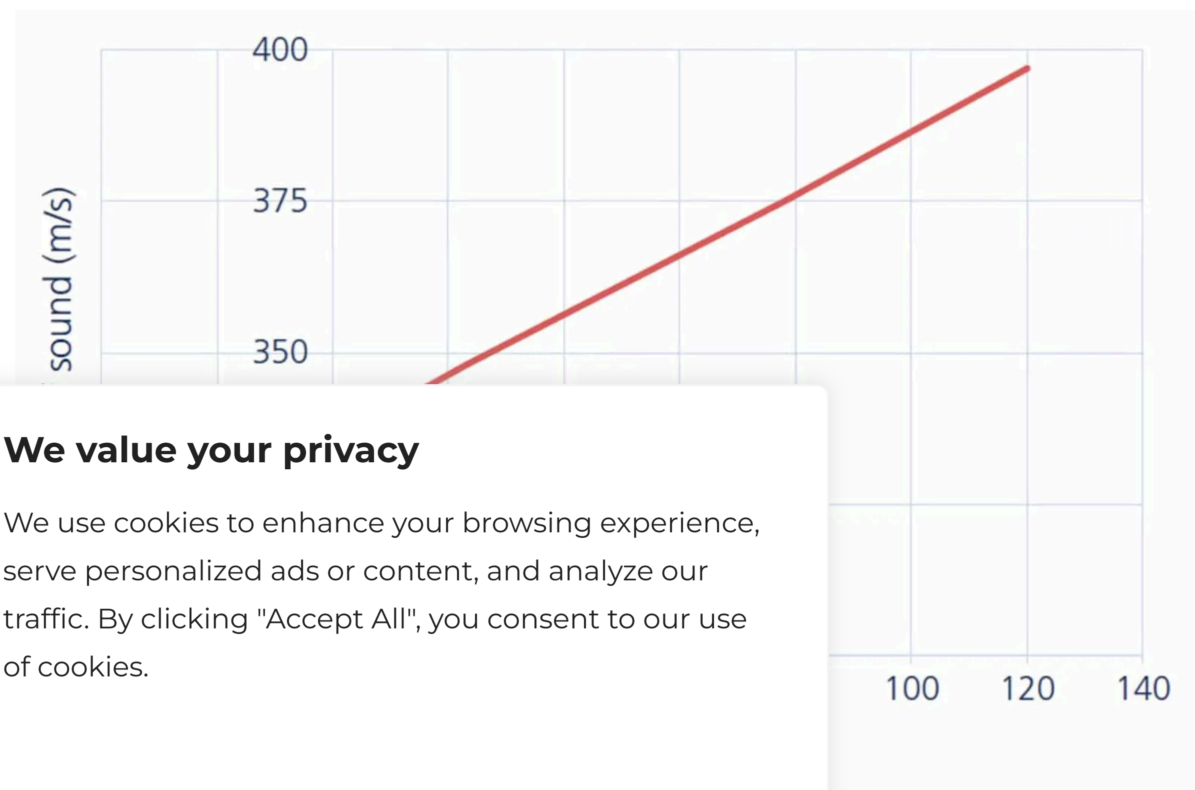




Temperature vs. the speed of sound

If we use an ultrasonic sensor to detect an object or perform a level or distance measurement. Ideally, it is done very accurately. In order to do that, variables have to be taken into account that can influence the operation of the ultrasonic sensor such as: temperature, speed of sound through air, humidity, air pressure and the damping of sound.

Temperature has the greatest influence on the speed of sound. The relationship between temperature and speed of sound is almost linear. Sound travels through air, the medium, at a speed of 344 meters per second at a temperature of 20 degrees. When it gets warmer, the speed of sound increases. To compensate for this, most microsonic ultrasonic sensors have an internal temperature compensation. This means that those ultrasonic sensors measure the current temperature and compensate for the measured value. This improves the accuracy of the measurement.

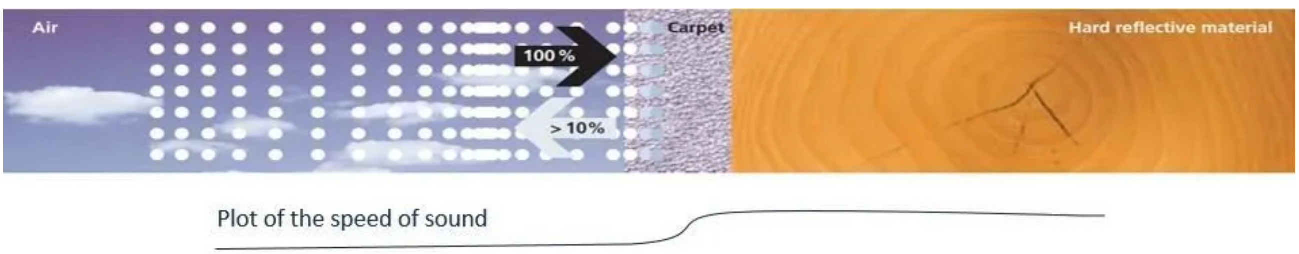
Frequency vs. maximum measurable distance

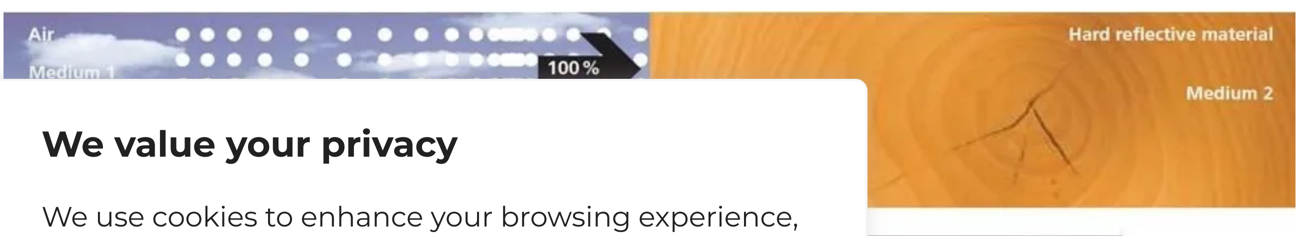
The frequency of the sound partly determines the distance that sound can travel. The lower the frequency, the greater the distance. Just think of a music festival, the low tones of the music can still be heard from a great distance, while the high tones fade much faster ...

For an ultrasonic sensor applies that when sound pulses are used at 40 kHz, a distance of approximately 10 meters can be covered. When the ultrasonic sensor uses pulses at 400 kHz, than the maximium distance is only about 65 cm.

With an ultrasonic sensor, an accuracy of up to 1% of the set measuring range can be
accuracy of 1 mm at a distance
sound is emitted at a fixed
ne sensor, the greater the

Object reflectivity





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...ine the degree to which the ...od detection, a high degree of sound reflection is necessary.

Good sound-reflecting materials

In the example in the image, sound moving through air (the medium) is reflected on wood (the object). 99.9% of the emitted sound returns to the sensor. Examples of highly reflective materials are: wood, stone, glass, plastic. liquids, steel, stainless steel, glue, concrete, rubber and paint.

Less sound-reflecting materials

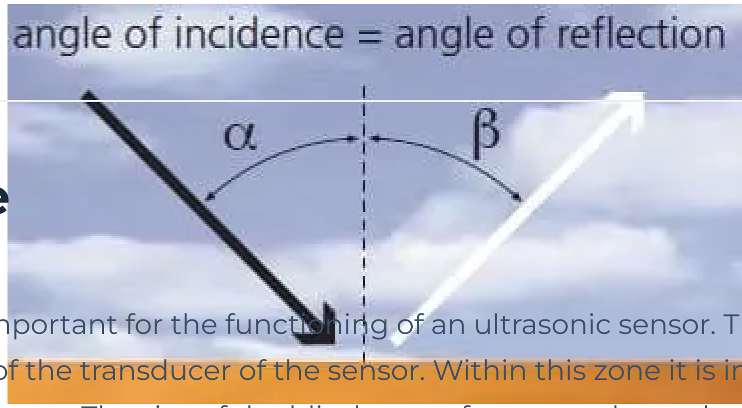
There are also materials that absorb sound or let it through. These are objects with poor reflective properties for an ultrasonic sensor. In the example in the image, a piece of carpet is applied onto the wood. This makes less than 10% of the emitted sound pulse reflect back to the sensor. 90% is thus absorbed by the carpet. Examples of materials with poor sound reflection are: carpet, woven materials with an open structure, foam, cotton, powders filled with a lot of air, etc.

Angle of incidence is equal to angle of reflection

The object that has to be detected needs to be reflective. This allows the emitted sound to be reflected. The following rule applies to this: angle of incidence equals angle of reflection. The sensor has to be positioned perpendicular to the object in order to receive a reflected sound pulse and thus perform a good detection. A rule of thumb for mounting the sensor is: a maximum of a 3° angle relative to the object.

When the surface of an object is uneven, the angle of incidence can be greater. This is because the sound diverges and is deflected into multiple directions. Examples of these materials are coarse materials suchs as sand, sandpaper, potatoes, etc.

For making an ultrasonic sensor work in a certain application, the advise always remains:



Blind zone

The blind zone is important for the functioning of an ultrasonic sensor. This zone is the first area, right in front of the transducer of the sensor. Within this zone it is impossible to perform measurements. The size of the blind zone of a sensor depends on a variety of factors. These are:

1. The duration of the sound pulse;
2. The frequency with which sound moves through air (or another medium).

The combination of these two factors make it impossible to perform a reliable measurement in the first area right in front of the sensor. This is because of the fact that an ultrasonic sensor emits sound and has to switch in order to receive these. Transmitting and receiving can not be done simultaneously, so a blind zone is formed in the measurement. When an object is in the blind zone, it is not detected. As a rule of thumb, it can be said that the blind zone lays between 5% and 10% of the maximum measuring range of the sensor: the shorter the detection range, the smaller the blind zone.

For what applications can ultrasonic sensors be used?

It is now clear what an ultrasonic sensor is and how it works. How can we translate this to a usable application? The following areas of application, below here, are good examples for

From clear water to dark coffee, the ultrasonic sensor detects almost every liquid. Ultrasonic sensors are used in a multitude of applications in the Food & Beverages (F&B) industry, such as a level measurement in filled bottles with beverages like soda. Other applications are a full or empty detection of soup cans, packages of stir frying sauce, pots of peanut butter or bottles of soy sauce.

Ultrasonic sensors are not susceptible to color. Another frequently seen application is the detection of all kinds of sweets that are packaged into assortment packages. A popular application is a level measurement in cans of paints. Whether the paint is lemon yellow, ruby red, steel blue or deep black it is possible to detect insusceptible to color with the help of an ultrasonic sensor.

Textile, leather and foam materials are known for their sound-absorbent properties. Ultrasonic sensors of microsonic are capable of performing a correct measurement despite the high levels of sound absorption of these materials.

Detecting transparent materials

Coarse, grainy or dense sand

Less to no contrast

Ultrasonic sensors are insensitive to transparency. Transparent objects like glass, plastic or extremely thin foils can be detected without any trouble. Examples of applications like this are plastic packages that contain bread and meat products, the shrink film wrapped around prepackaged cheese or detecting the presence of seal foil on a package of fresh spreads. Every application where transparent objects are involved, ultrasonic sensors can provide a solution when it comes to realize a reliable detection.

ntly but is also insusceptible to tecting applications that urement of shell sand or the h grinding dust from a CNC addition, ultrasonic sensors are form reliable level

st (or none at all) are detected without any effort by ultrasonic sensors. White on white, black on black the color doesn't matter. With low contrast, or none at all, between the object and the background an ultrasonic sensor is, as one of the few sensors, capable to distinguish these. An example of this is the presence of rubber granulates in a black storage bin or the detection of stainless steel parts in a stainless steel sump tray.

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