Ultrasonic Sensors Knowledge (Part 4): Influences on Measurement Accuracy

With **ultrasonic sensors**, measurement accuracy usually refers to the **absolute accurac**y of the measured value at the **analog output**. Based on the echo transit time, the **measurement accuracy** of an **ultrasonic sensor** depends on several **physical parameters**. These **parameters** relate to the **air** as well as to **internal tolerances**.

Absolute accuracies of 1% to 3% are realistic in industrial applications for ultrasonic sensors in the operating range of -25°C to +70°C

Environmental influences

Air temperature

Air temperature has the greatest impact on the measuring accuracy of an **ultrasonic sensor**. After the transit time of the reflected **ultrasonic pulse** has been measured, the sensor calculates the **distance to the object** using the **speed of the sound**. However, as the air temperature changes, the speed of sound changes by 0.17% per degree Kelvin. Almost all **Pepperl+Fuchs ultrasonic sensors** have a temperature probe to **compensate for this effect**. This probe measures the **ambient temperature** and the sensor corrects the **temperature-related distortion of the measured values** (see temperature compensation).

Humidity

Humidity has negligible influence on the speed of sound at room temperature and at lower temperatures. However, at higher air temperatures, the **speed of sound increases as humidity increases**.

Air pressure

The speed of sound decreases by less than 1% between sea level and 3,000 m altitude. Atmospheric fluctuations at a specific location are negligible and the **effects on the speed of sound are hardly measurable**.

Air currents

If the object has the **reflective properties** of the **standard reflector,** regular air currents (wind) have no effect on **ultrasonic measurement** to speeds of 7 Bft (50-61.5 km/h). Stormy weather or hurricanes can cause unstable measurements (with loss of signal). Regarding changes to the **speed of sound**, no general conclusions can be drawn. This is because **air current direction** and **air current speeds** constantly change. For example, particularly hot objects, such as red-hot metal, cause **significant air turbulence**. The ultrasound can be scattered or deflected in such a way that no evaluable echo is returned.

Paint mist

Paint mist has no detectable effect on the operation of **ultrasonic sensors**. However, the mist should not be allowed to settle on the **active transducer surface** to avoid compromising the **transducer's sensitivity**.

External noise

External noise is distinguished from the desired target echoes and generally does not cause malfunctions. If the source of disturbance has the same frequency as the **ultrasonic sensor**, the level of the external noise must not exceed the level of the target echoes. This can occur when **filling a silo with stone,** as an example.

Types of gas

Ultrasonic sensors by Pepperl+Fuchs are designed for operation in atmospheric air. Operation in other gases (for example in carbon dioxide) can cause serious **errors of measurement** or even total loss of function due to deviations in the **speed of sound and attenuation**.

Temperature compensation

Ultrasonic sensors operate using the **echo transit time method,** which means the time that is elapsed between the **emitted ultrasonic pulse** and when the **received echo** is evaluated. The **ultrasonic sensor** calculates the distance of the object from the speed of sound. When sound is propagated in air, the **speed of sound is about 344 m/s** at room temperature. However, the speed of sound is temperature-dependent and changes by approximately 0.17% with each degree Celsius. These changes affect the transit time and can distort the calculated distance. Most **ultrasonic sensors** by Pepperl+Fuchs have a **working range of -25° C to +70° C**.

Without temperature compensation and at a **measuring distance** of 100 cm, a 20° C change in temperature would cause a measurement error of -8.5 cm at 70° C and +7.65 cm at -25° C.

Therefore, most of these **ultrasonic sensors** are equipped with **temperature probes** whose measurements are used to **correct the measured distances**. This compensation is performed over the entire working range of the **ultrasonic sensors** from -25° C to +70° C and allows **measurement accuracies** of approximately ±1.5% to be achieved.

Accuracy

Accuracy/absolute accuracy refers to the **difference between the output value** that is measured by the **ultrasonic sensor** and the **actual target distance**. From a practical viewpoint, absolute accuracies of 1% to 3% are realistic in **industrial applications for ultrasonic sensors** in the **operating range of -25° C to +70° C**. Higher accuracies can be achieved in very stable ambient conditions. In this case, it is advisable to turn off temperature compensation (using the programming tool).

Another possibility would be to use an **ultrasonic reference sensor**. This approach involves **mounting a second sensor** of the same type parallel to the **measuring sensor** and aligning it to a fixed object. If **ambient conditions** in the measuring range change, the distance to the object will also appear to change due to the **altered speed of sound**. The measuring value must then be corrected by the value of this error.

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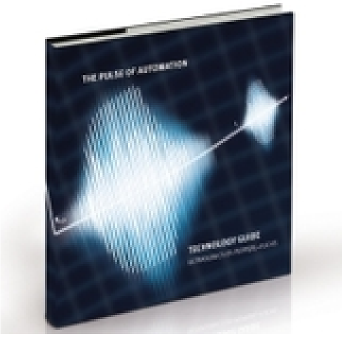

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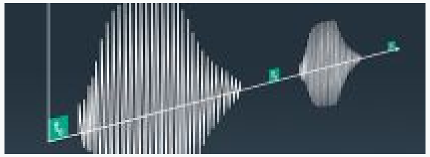

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Literature

- The Pulse of Automation - Product Overview Ultrasonic Sensors (PDF, 3.2 MB)

More Information

- Ultrasonic Sensors Knowledge (Part 1): Technology and Functionality in a Nutshell
- Ultrasonic Sensors Knowledge (Part 2): Influences on the Sound Beam
- Ultrasonic Sensors Knowledge (Part 3): Different Operating Modes
- Ultrasonic Sensors Knowledge (Part 4): Influences on Measurement Accuracy
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