Paving the Way with Ultrasonic Sensing

Mubina Toa

Imagine a commute to work where, with the press of a button, your electric car automatically drives up to you, opens its door to let you in, navigates on its own through traffic to find the quickest route, pulls up to a garage with automatic gates, parks itself in an available spot, drops you off and charges itself on its own while parked. With the advancement of electric self-driving cars, this future is already starting to become a reality.

Sensors are at the heart of automation – embedded not only within vehicles to make smart driving decisions, but also in the surrounding environment to create a network of intelligence. With an interconnected system of sensors and data mapping the world as we see it, the road to innovation is truly limitless.

How Ultrasonic Technology Performs Five Unique Tasks to Improve the Driving Experience

Ultrasonic sensors use sound waves to detect the presence or proximity of an object. This is done by transmitting a sound wave in the ultrasonic frequency band and listening for the return echo, which would be the result of the sound wave bouncing off an object in range. Time of flight describes the round-trip time it takes for a transmitted sound wave to come back to the receiver after bouncing off an object. Figure 1 is a simple formula that calculates the distance of an object from the ultrasonic sensor:

$$d_{oneway} = \frac{t_{RoundTrip} \times v_{Sound}}{2}$$

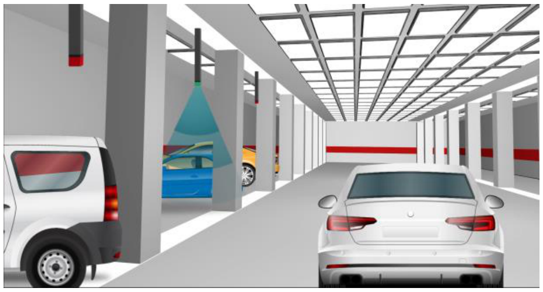
Figure 1. Equation 1

Although many technologies can detect presence, proximity and position, ultrasonic is a popular choice because of its low system cost, performance in dirty environments, and ability to detect glass surfaces and perform in all lighting conditions.

Let's explore how ultrasonic technology performs five tasks in and around the vehicle to improve the driving experience.

1. Garage Gate Sensing

Gate sensors are implemented in garages, parking lots and other facilities for ticketing and security purposes. Ultrasonic sensors are beneficial here for their ability to operate indoors, outdoors and in any lighting condition. Ultrasonic technology makes it easy to detect larger objects like cars and motorcycles and dismiss smaller objects like animals and debris, therefore reducing the rate of false positives presented by other presence-sensing technologies.



2. Parking Spot Sensing

Larger garages are adopting parking spot sensors to indicate whether a parking spot is empty or occupied. These sensors send information to a central server, which aggregates the number of empty and occupied spots in a certain area or floor of a garage and displays this information in external displays to help guide drivers to open parking spots. Sensors can be mounted on the floor or ceiling, but are typically mounted on the ceiling for easy installation in existing facilities. To conserve power, sensors can be duty-cycled and sampled once every few minutes to maintain a pretty accurate count.

3. Park Assist

In the past, ultrasonic park assist sensors were employed only in higher-end vehicles, helping drivers understand their surroundings by detecting obstructions. With the cost of ultrasonic sensors decreasing and their functional capabilities increasing, they are becoming more prevalent in lower- and mid-end vehicles as well. As the push towards autonomy progresses, employing ultrasonic park assist sensors in conjunction with other sensors will aid in the automated parking of vehicles. Industry standards require that ultrasonic park assist sensors sense at a range of up to 5 m and detect objects as narrow as a 75-mm wide.

4. Wireless Charging Pads/electric Vehicle Charging Stations

As electric vehicles become more common, so are charging stations. They typically come in one of two topologies: a wireless charging pad or a station that's similar to a traditional gas station. Wireless charging pads are typically mounted on the floor of a parking spot, waiting for a car to drive up over it. Ultrasonic sensors ensure that the charging pad is fully covered under the vehicle to ensure best-case efficiency when charging. An embedded sensor can also ensure that there are no unintentional objects in proximity (such as a pet) before charging initiates. Wireless charging stations often have sensors on them as a measure to conserve electricity by keeping the station in sleep mode until it detects a car in proximity.

5. Kick-to-open Trunks

Kick-to-open trunks or smart trunk openers are becoming more prominent in vehicles. They enable hands-free opening of the trunk by hovering a foot below the bumper. Other body sensors located around doors and trunks can make sure that there is enough space to open and close them without hitting a wall, pole, another vehicle or a human. Capacitive sensing is used in these applications, but due to sensor failures in icy or snowy conditions, ultrasonic sensing is preferable, as such environments don't affect its performance.

Get Started with TI's Ultrasonic Technology

Figure 2 below is a screenshot from the PGA460-Q1 ultrasonic sensor signal conditioning evaluation module with transducers, which helps you evaluate the performance of TI's ultrasonic sensing IC in detecting obstructions and calculating Time-of-Flight. The figure shows the echo output (the yellow line) and time-varying gain and threshold registers (the white and blue lines). The built-in threshold registers make it easy for many of these applications to decide when to perform a function. For example, in the parking spot sensing example, it's possible to set the threshold to ignore objects like a small animal but still detect desired objects like vehicles, which produce a stronger signal.

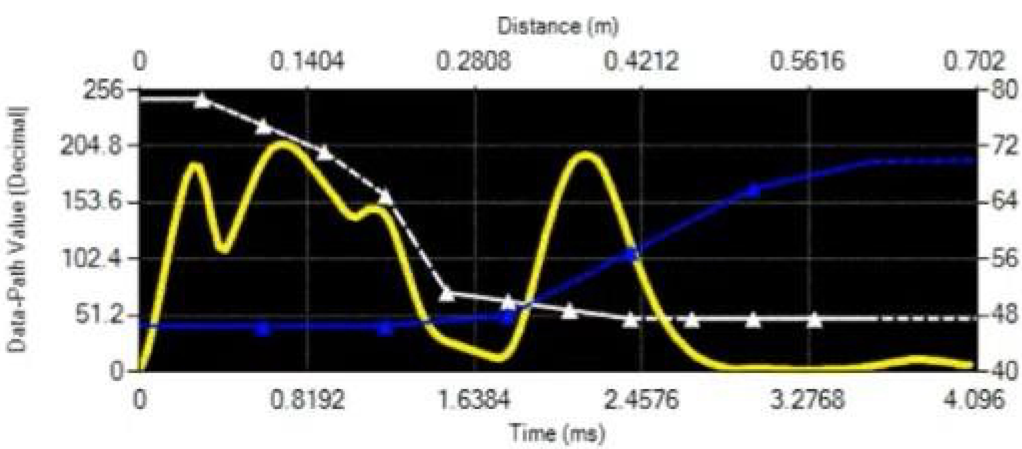


Figure 1. PGA460 Ultrasonic GUI

Ultrasonic sensing is a beneficial technology for proximity and obstruction detection. It allows for intelligent decision making in vehicles, enabling them to sense the world around them to automate processes, improve efficiency and enhance safety.

Additional resources:

- EVM: PGA460EVM
- Application note: PGA460-Q1 in Ultrasonic Park Assist (UPA)
- Reference design: Ultrasonic Kick-to-Open Reference Design