

Technical Bulletin

Transformer Solutions for Ultrasonic Sensing

Overview

Ultrasonic sensing technology has been around a long time and is a cost-effective solution for short distance object detection. As shown in Figure 1, the technique measures the time interval between the sending of an ultrasonic signal and the return of the signal's reflection to detect the location of the target objects.

More accurate and reliable high-performance ultrasonic sensors are becoming available, and the demand for this technology (and its essential components) is growing, especially for advanced driver-assistance systems (ADAS) and automated driving systems in the automotive industry. More and more sensors are needed as the level of system complexity increases. Automotive parking assist and collision warning are just two of the lead systems in this sensor growth. Convenience items like trunk-opening sensing are also driving demand as OEMs look at ways to deploy this cost-effective technology. Ultrasonic sensing also plays an important role in many industrial automation applications like liquid level detecting and anti-collision on work transportation platforms. Other fields of applications include medical, energy, manufacturing, and smart grid.

Automotive Applications

- Automated parking assist
- Blind-spot warning
- Presence and proximity detection
- Automotive kick-to-open lift gates (smart trunk opener)

Industrial Applications

- Liquid level sensing and inventory management
- Robotics landing assist and obstacle detection
- Anti-collision on aerial work platforms
- Forklift monitoring and control
- Industrial door-opening sensing

Automotive Ultrasonic Transducer Driver

Semiconductor manufacturers are now offering highly integrated system-on-chip (SoC) products which integrate the transducer driver, signal conditioner, diagnostics and advanced DSP core in a single compact package. These devices have a complementary low-side driver pair that can drive a transducer either in a transformer-based topology using a step-up transformer or in a direct-drive topology using external high-side FETS. These full-featured products provide the designer with a great deal of flexibility and their high level of integration results in the smallest solution size possible.

A transformer-driven solution may use a center-tapped boost transformer to drive a large excitation voltage across the ultrasonic transducer and, thus, create the desired sound pressure level (SPL). This method is recommended for most ultrasonic applications today to achieve maximum ranging distance.

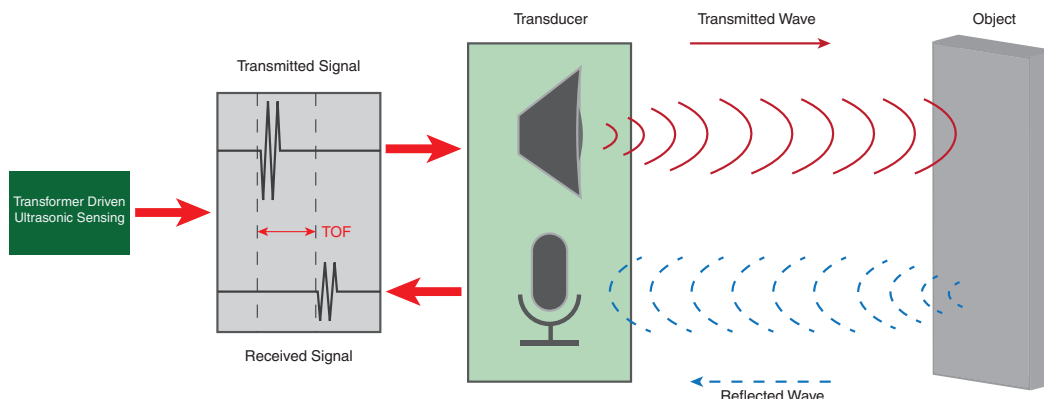


Figure 1. Ultrasonic sensing schematic

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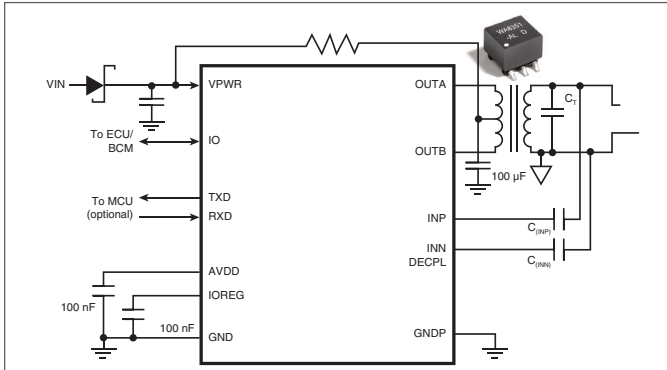


Figure 2. Typical Application Diagram (Transformer Drive)

Coilcraft Transformers for Ultrasonic Sensing

Traditionally, tunable-inductance transformers have been used with ultrasonic transducer drivers. But the disadvantage of tunable transformers is that the inductance tends to drift with temperatures, possibly making the system unstable. Coilcraft's ultrasonic transformer has a fixed inductance value and is stable up to ambient temperature $T_A = 125^\circ\text{C}$ (Figure 3). This feature is critical for accurate and reliable system performance, especially in automotive environments.

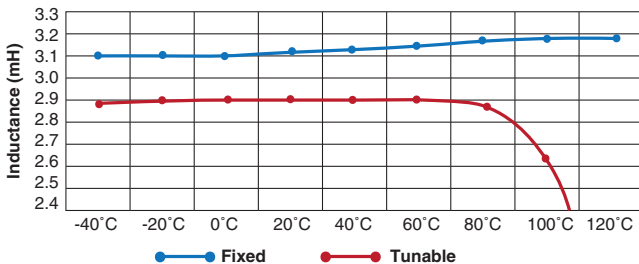


Figure 3. Coilcraft's ultrasonic transformer has a fixed inductance value and is stable up to 125°C ambient

Coilcraft's WA8351-AL SMT Transformer is optimized for the PGA460-Q1 Automotive Ultrasonic Signal Processor and Transducer Driver from Texas Instruments.

- Compact, low-profile package – just 8.2 × 6.6 × 5.4 mm
- Optimized for a variety of ultrasonic transducers
- High-performance for ultrasonic time-of-flight (TOF) sensing
- Ideal for automotive ADAS and industrial applications (e.g., liquid level sensing, flow sensing, or fluid ID)
- AEC-Q200 Grade 1 (–40°C to +125°C ambient)

Application Examples

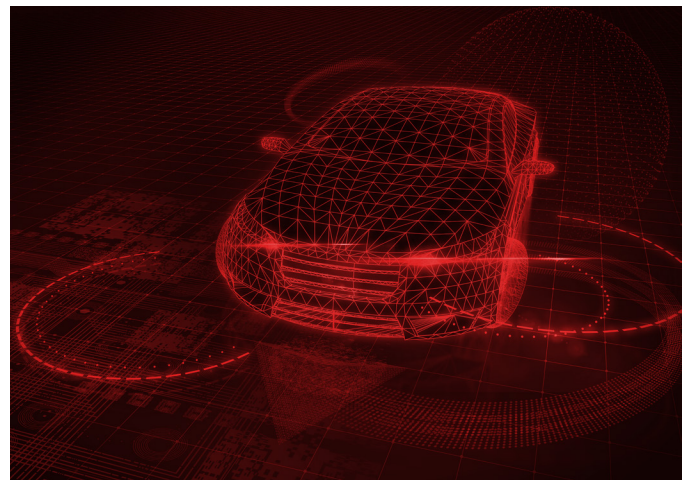
Ultrasonic Park Assist

The Parking Assist System (PAS) identifies and measures distance between a vehicle and objects in relatively close proximity. The distance information can then be communicated to the driver with audio and/or visual indications. This application uses ultrasonic sensors with transformer-driven transducers almost exclusively.

The PGA460-Q1 on-chip ultrasonic transducer driver from Texas Instruments can accurately detect objects from less than 10 cm away to more than 7 meters, a much wider range than today's typical requirements.

To achieve long-distance ranging, an ultrasonic boost transformer is recommended to excite the transducer to the maximum desired SPL level. The transformer-driven solution offers both superior long-distance ranging and the capability to discern objects at close proximity accurately by reducing and fine tuning the transducer decay ring time. If the ring time is too long, the ringing interferes with the receiver's ability to pick up the reflected signal.

The TIDA-01597 reference design from Texas Instruments uses three of their PGA460-Q1 ultrasonic transducer drivers and three ultrasonic transformers to provide object detection at a distance from 25 cm to 2.5 meters. Typically, these systems have required between four and 16 sensors strategically placed around the vehicle to provide the desired detection.



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The Kick-to-Open System

The Kick-to-Open, or Smart Trunk Opener (STO), is being adopted by many automotive OEMs as a popular optional feature. It allows hands-free access to open the trunk with a simple kicking motion near the rear bumper.



STO allows hands-free opening of the trunk with a simple kicking motion

Ultrasonic sensor technology has advantages over the traditional capacitive sensing method to provide better sensitivity. Since the system must detect the kicking motion of the operator, the near-field detection must be optimized. Because of this requirement, the transformer drive topology (Figure 2) is also recommend here since the ultrasonic ringing decay profile is more predictable and provides more accurate short-range performance.

Summary

Coilcraft's high quality ultrasonic transformers are key components that can help to achieve wide-ranging, accurate ultrasonic distance sensing. These transformers are temperature-stable and AEC-Q200 qualified, making them an important part of many ultrasonic ranging applications.