DESIGN SOLUTION 7098

SEEING IS BELIEVING: GIVE YOUR LIDAR ADAS SYSTEM 20:20 VISION

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Abstract: In this design solution, we explain why the transimpedance amplifier (TIA) and comparator are critical elements in the LIDAR receive signal-chain and show how new TIA and comparator ICs improve the accuracy of ADAS systems which use LIDAR technology.

Introduction

After a hard work week, you get that fantastic Friday evening feeling as you sit back and watch the big game on your recently purchased, 75-inch 4K UHD TV when suddenly–Doh!—you realize you've left your glasses at the office. What's the point in having a TV with the best picture in the world if you cannot see it properly? In some ways, light detection and ranging technology, better known as LIDAR, currently used in many advanced driver assistance systems (ADAS, **Figure 1**) and which will underpin the future development of autonomous vehicles, suffers from the same limitations as human vision.

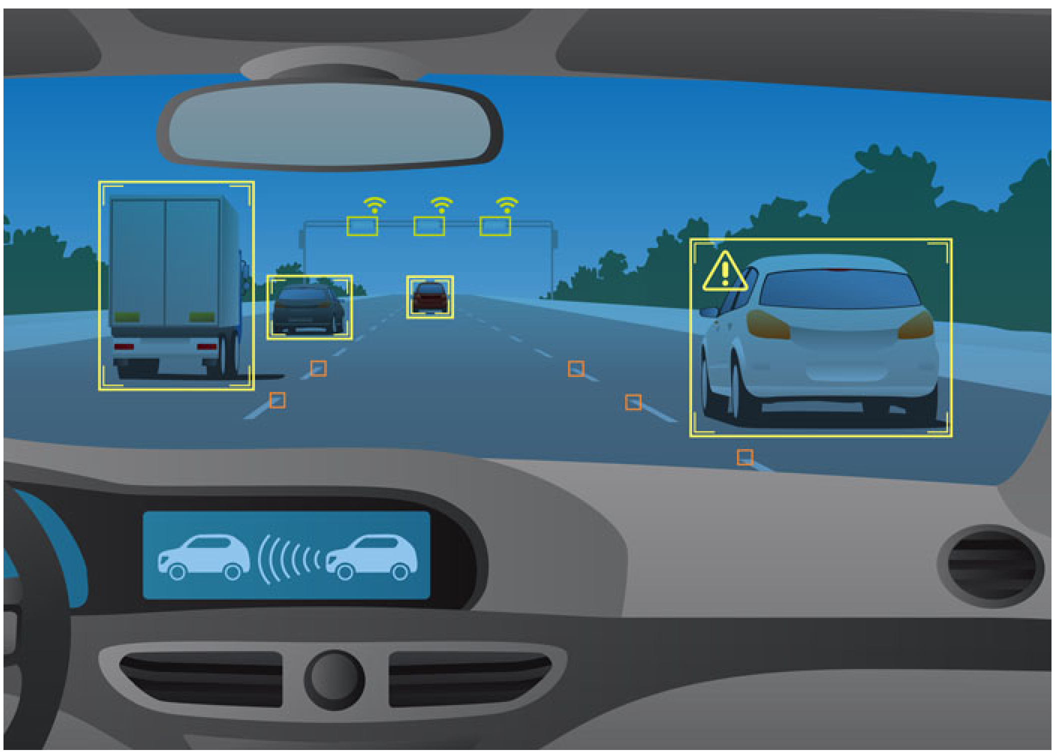

Figure 1. Automobile using ADAS.

While substantial research and development is being undertaken to improve the optical front-end, the quality of the picture which a LIDAR system produces of its environment is equally dependent on the performance of the back-end receiver electronics. Two of the critical components in the receive signal-chain are the transimpedance amplifier (TIA) and the comparator. In this design solution, we review the key functional requirements for these components before presenting new TIA and comparator ICs designed to bring unsurpassed levels of accuracy to future LIDAR systems.

How LIDAR Works

A simplified block diagram of a LIDAR system is shown in **Figure 2**. Light transmitted from a multi-dimensional laser beam is reflected back from an incident object and detected using a photodetector (or avalanche photodiode). The output current from the detector is converted to a differential voltage signal using a TIA, and a comparator is then used to indicate that the reflected signal has been successfully detected (by exceeding a preset threshold). Since the speed of light is constant, the delay between transmitted and received light signals (time-of-flight) can be measured and calculated by the MCU (sometimes with the assistance of a dedicated signal processing IC).

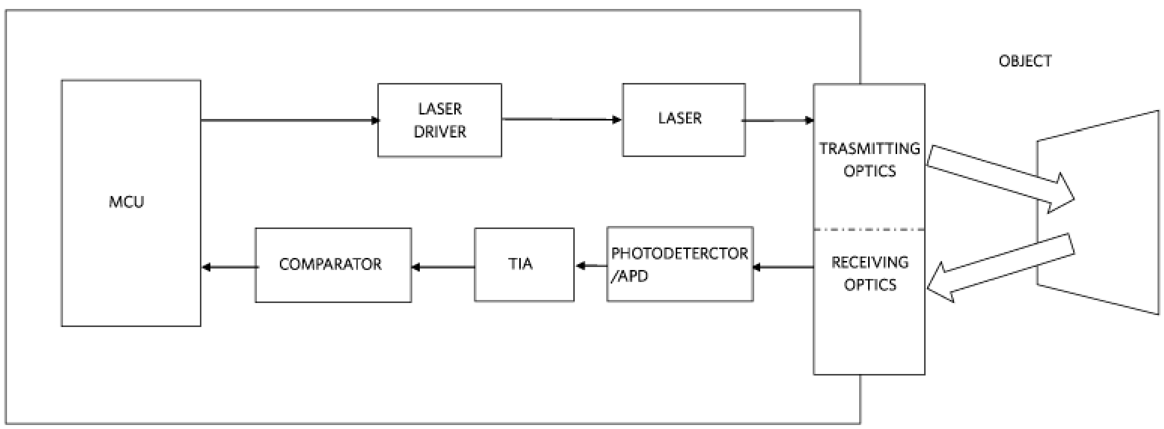

Figure 2. LIDAR system block diagram.

Selecting a TIA

The performance of the TIA in the receiver signal chain is critical to overall system operation. To detect obstacles (fixed or moving), it requires a wide enough bandwidth to capture all details in variety of different road conditions. Higher bandwidth allows more pixels to be acquired, helping to achieve better distance resolution. The TIA should have the lowest possible noise so as not to distort the signal being transmitted and avoid misinterpretations over longer distances. Selectable gain allows for increased dynamic range of input current (possibly eliminating the need for another amplification stage later in the signal chain). The IC should also have the ability to safely withstand and quickly recover from large, transient input overload currents. Also, since the optical front-end of a LIDAR system consumes a significant amount of power, ideally it should be possible to place the TIA in low-power mode when the channel is not in use. The TIAs shown in Figure 3 have been designed specifically to meet these criteria.

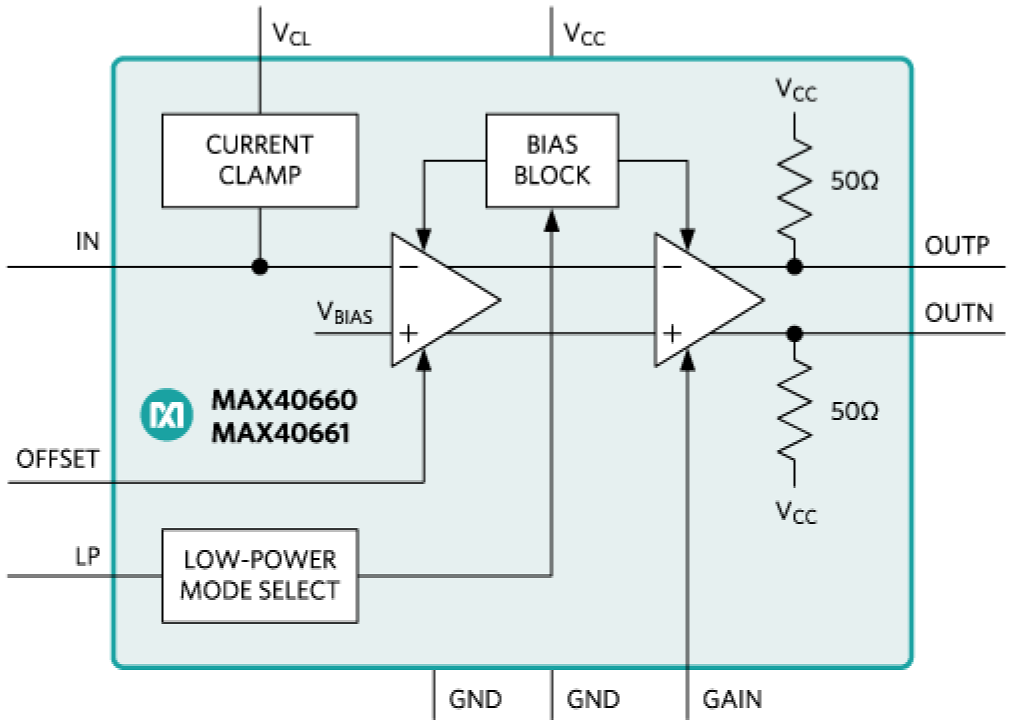

Figure 3. MAX40660/MAX40661 transimpedance amplifiers for automotive LIDAR.

With bandwidth options of 160MHz (MAX40661) and 490MHz (MAX40660), they can amplify input current pulses of only a few nanoseconds in duration, providing greater resolution. A noise figure of 2.1pA√Hz, allows systems to operate over much longer distances. Dynamic range can be adjusted using two pin-selectable transimpedance values of 25kΩ and 50kΩ, potentially eliminating the need for a subsequent amplification stage. These parts are robust enough to withstand input currents of up to 2A for 10ns and have a fast overload current recovery time of only 2ns (up to 100mA). When not in use, they can be placed in a low-power mode, consuming only 26mW of power. These ICs are AEC-Q100 qualified and their FMEDA results are available to assist ASIL-compliance computations at the system level. They are available in a 3mm x 3mm, 10-lead TDFN package with side-wettable flanks, making them excellent choices for automotive LIDAR applications.

Choosing a Comparator

While it is clear that a comparator used in a LIDAR application should have the smallest possible propagation delay, it may not be as obvious that its dispersion figure is equally important. The dispersion of a comparator is the variation in propagation delay caused by changes in the input signal overdrive voltage and/or slew rate and should also be as low as possible. For example, a typical comparator with a dispersion figure of 1.6ns will account for a large measurement error of 24cm, if used in a LIDAR application. For these reasons, the comparator shown in **Figure 4** is an optimal choice.

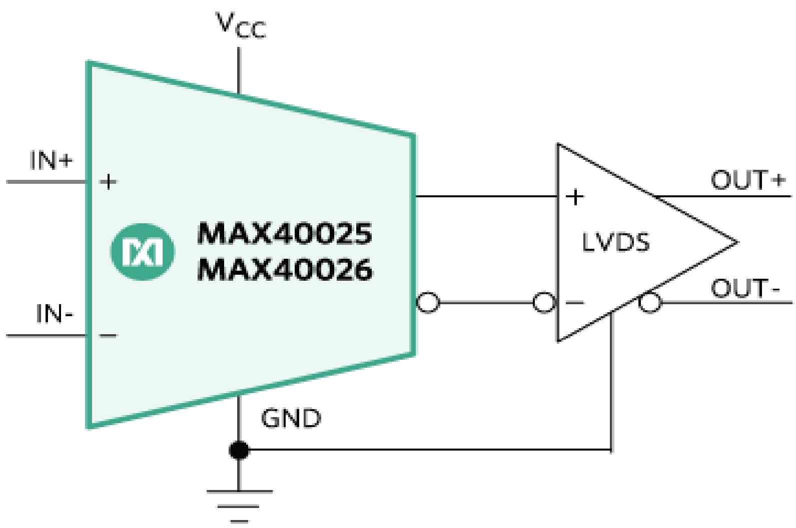

Figure 4. 280ps high-speed comparator with ultra-low dispersion and LVDS outputs.

With a propagation delay of only 280ps and a low overdrive dispersion figure of 10ps (for V_{OD} = 20mV to 100mV), as shown in **Figure 5**, it accounts for a measurement error of 0.15cm. The low-voltage differential signaling (LVDS) output provided helps to minimize power dissipation (39.4mW with a 2.7V supply) while also allows for easy interfacing with many FPGAs and CPUs. Complementary outputs help to suppress common-mode noise on each output line (80dB typical).

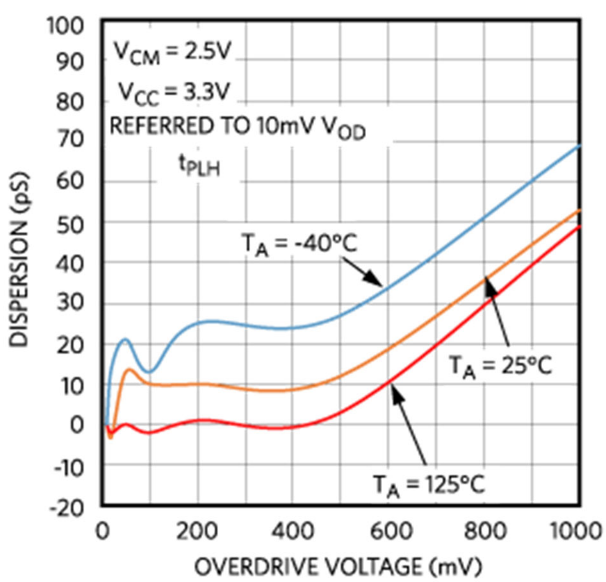

Figure 5. Dispersion vs. overdrive voltage for MAX40026.

For automotive applications, the MAX40026 is available in an AEC-Q100 qualified, 2mm x 2mm 8-pin TDFN, side-wettable package. For industrial or other applications, the MAX40025A is available in a 1.218mm x 0.818mm, 6-bump wafer-level package (WLP). A variant of this part, the MAX40025C is available without input hysteresis, as summarized in Table 1.

	MAX40025A	MAX40025C	MAX40026
Hysteresis (mV)	2.5	None	1.5
Package	WLP	WLP	TDFN

Table 1. Summary of MAX4002X Variants

Summary

LIDAR technology is currently used in many automobile ADAS systems and will become increasingly important in the future development of autonomous vehicles. While much attention has been placed on the operation of the optical front-end, we have shown how the electronic components in the receiver signal chain are critical to overall system performance. In this design solution, we have presented TIA and comparator ICs, which can provide unprecedented levels of accuracy to LIDAR systems and other time-of-flight applications while meeting stringent safety standards.